SECTION 6

PART A

ENGINE S325.3

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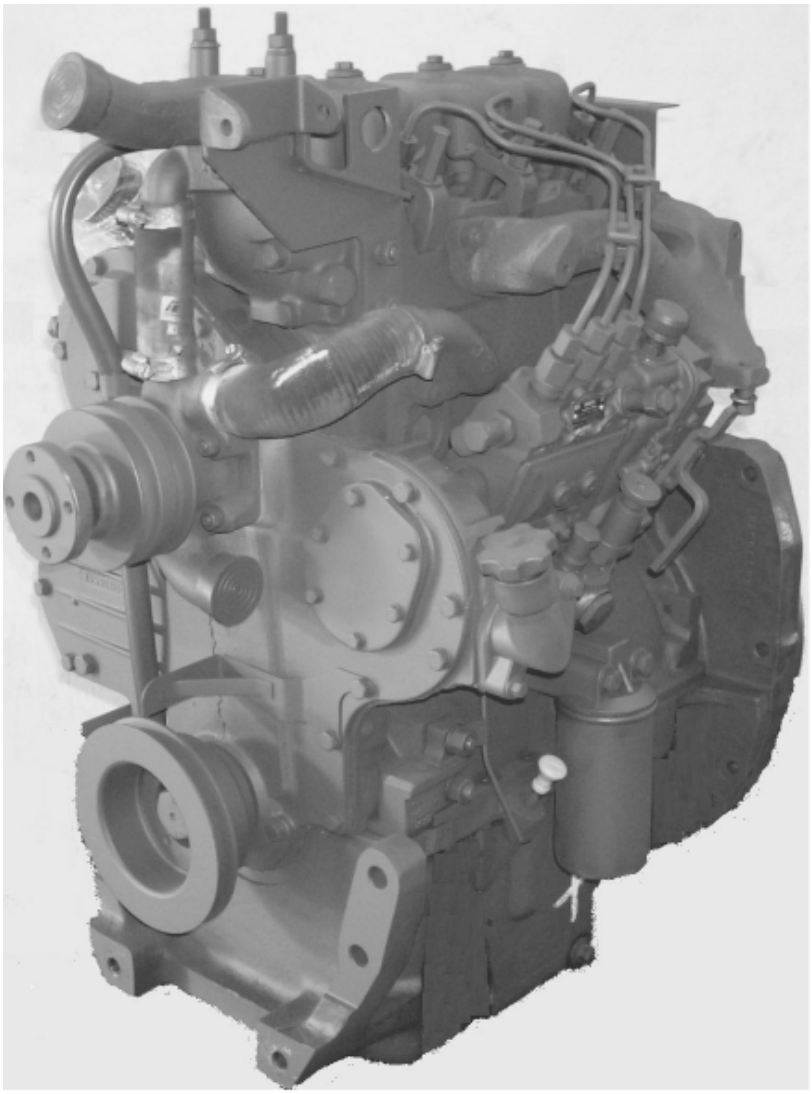
Section A

ENGINE VIEW



ENGINE TYPE AND NUMBER LOCATION

The engine number is stamped on the camshaft tunnel of the cylinder block – on the right side of the engine.

When requesting information regarding the engine, the number should be quoted.

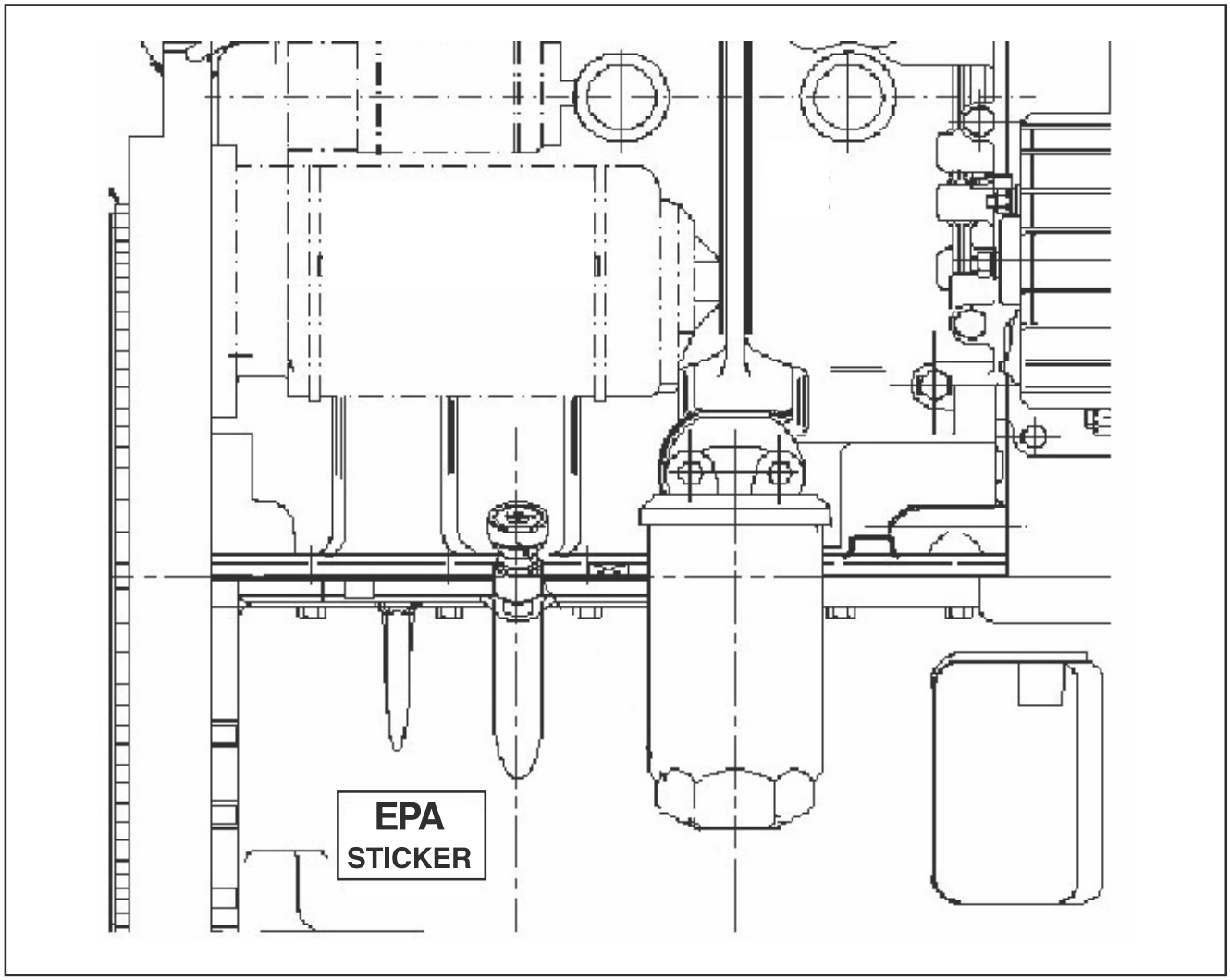
S 325.3 Engine : *Called S325 Dot Three Engine*

The suffix number “called Dot Three” indicates development of S325.2 engine with the following modified components to meet US TIER II

Alfin Piston with re-entrant bowl (3-ring pack), ‘P’ type Injector, Spill timing 14.+/- 1° BTDC.

ENVIROMENTAL PROTECTION AGENCY (EPA) LOCATION

The EPA Sticker is located on both sides of the engine oil sump



Section B
S325.3 DIESEL ENGINES

ALL THREADS USED ON S 325.3 ENGINES, ARE METRIC SERIES
EXCEPT THE COMPONENTS INDICATED BELOW

(Refer annex for modification)

1.	Stud/Nut/Setscrew, Cylinder Block to Cylinder head	...	7/16" – 20 UNF
2.	Bolt and Nut, Connecting Rod	...	7/16" – 20 UNF
3.	Balance Weight Setscrew	...	7/16" – 20 UNF
4.	Bridge Piece Timing Case (Applicable for earlier type)	...	5/16" – 24UNC
5.	Plug Cylinder Head	...	1/2" – 14 PTF
6.	Thermostart fixing hole in the induction manifold	...	7/8" – 14 UNF
7.	Union, Rocker oil feed in Cylinder head	...	1/8" – 27 NPSI
8.	Oil pressure gauge connection on pressure rail	...	1/4" – 18 NPSI

RECOMMENDED TORQUE TENSIONS

The following torque figures will apply with the components lightly oiled before assembly :

Cylinder head nut and setscrews (NRT)*	...	80	lbf. ft.	10.8	Kgf. m.	(7/16-20 UNF)
Connecting rod nuts (Cadmium plated)	...	45	lbf. ft.	6.2	Kgf. m.	(7/16-20 UNF)
Connecting rod nuts (Phosphated)	...	60	lbf. ft.	8.2	Kgf. m.	(7/16-20 UNF)
Main bearing setscrews	...	115	lbf. ft.	15.9	Kgf. m.	(M 14 x 2)
Balance weight setscrews	...	55	lbf. ft.	7.6	Kgf. m.	(7/16-20 UNF)
Idler gear retaining setscrew	...	50	lbf. ft.	6.9	Kgf. m.	(M 12 x 1.5)
Camshaft gear retaining setscrews	...	21	lbf. ft.	2.9	Kgf. m.	(M 8 x 1.25)
F.I. pump adapter to F.I. pump nut	...	45	lbf. ft	6.2	Kgf. m.	–
F.I. pump gear to adapter setscrews	...	21	lbf. ft.	2.9	Kgf. m.	(M 8 x 1.25)
Flywheel setscrew	...	80	lbf. ft.	11.1	Kgf.m.	(M 12 x 1.25)
Crankshaft pulley retaining setscrews	...	110	lbf. ft.	15.2	Kgf. m.	(M 22 x 2.5)
Atomiser securing nuts	...	12	lbf. ft.	1.7	Kgf. m.	(M 8 x 1.00)

NOTE : Cylinder head gasket used on S325.3 engines are 'Non-retorque' type. It should be fitted Dry. ***'Top Front'*** *mark should face the cylinder head. (Ref. Fig. E2 / Page 33 – For tightening sequence)*

* NRT – Non-retorque type gasket (New type now being used in all S3 engines in production)

This new type gasket does not require retorquing in predelivery inspection

Section B

Technical Data

Type	...	...	Three Cylinder, Four Stroke, Direct Injection
Aspiration	...	...	Naturally aspirated
Bore (Nominal dia)	...	...	3.6 inch (91,44 mm)
Stroke	...	...	5 inch (127 mm)
Cubic Capacity	...	...	152 inch^3 (2.5 litres)
Compression Ratio	...	...	18.5 :1
Basic Thread Form	...	...	Metric
Firing Order	...	...	1, 2, 3
Rotation	...	...	Anti-clockwise from the flywheel end
Tappet Clearance	...	...	0.012 inch (0.30 mm) Cold 0.010 inch (0.25 mm) Hot
Lubricating Oil Pressure	...	...	30/60 lbf/in^2 (2.1/4.2 kg/cm^2)
Injector Setting Pressure	...	...	235 bar (3410 psi)
Fuel Injection Pump	...	...	MICO inline type with mechanical governor, flange mounted.
Fuel Feed Pump	...	...	Integral with Fuel Injection Pump
Electrical System	...	...	12 Volts
Inlet valve opens	...	...	13° BTDC
Exhaust valve closes	...	...	10°A TDC
Total Inlet open period	...	...	236°
Total exhaust open period	...	...	236°
Injection timing (spill timing)	...	...	14+/- 1° B.T.D.C.
Air Cleaner	...	...	Dry Type Air Cleaner
Engine Ratings :			
Maximum Gross Rating kW (bhp)	...	...	28Kw (38.06 hp) @ 2000 rpm
Maximum Gross Torque NM (Kgm)	...	...	15.2 kgm (109 lbf.ft) @ 1400 rpm
Rating Standard	...	...	ISO 14396
Application	...	...	Tractor

De-Rating for Altitude

Where engines are called upon to operate in rarefied atmospheres occasioned by altitude, such engines should be de-rated.

Any necessary adjustments in this respect to the fuel pump should be carried out by the MICO dealer for the territory concerned.

Approximate Engine Weight

Basic weight (with alternator but without starter motor, flywheel housing) ... 204 Kg (450 lbs).

Typical installed weight (with starter motor, flywheel and flywheel housing) ... 290 Kg (640 lbs).

Approximate Engine Dimension

Length 22.95 inch (583 mm), Width 23.46 inch (596 mm), Height 29.33 inch (745 mm).

Manufacturing Data and Dimensions

The following data of clearances and tolerances are given as a guide for personnel engaged in major overhauls and the figures are those used in the factory for production purposes.

Cylinder Block

Height of Cylinder Block from Top and Bottom Face	...	13.7405/13.7435 inch (349.01/349.08 mm)
Parent Bore Dia. for Cylinder Liner	...	3.6875/3.6885 inch (93.66/93.69 mm)
Depth of Recess for Liner Flange (Cast Iron Liners)	...	0.152/0.148 inch (3.76/3.86 mm)
Dia. Recess of Liner Flange (Cast Iron Liners)	...	3.825/3.820 inch (97.16/97.03 mm)
Main Bearing Parent Bore Dia	...	2.9165/2.9175 inch (74.08/74.10 mm)
Camshaft Bore Dia. - No. 1	...	1.874/1.877 inch (47.60/47.68 mm)
Camshaft Bore Dia. - No. 2	...	1.864/1.867 inch (47.35/47.42 mm)
Camshaft Bore Dia. - No. 3	...	1.844/1.847 inch (46.84/46.91 mm)

Cylinder Liners - Cast Iron

Type – Production Liner	...	Dry- semi finished interference Fit
– Service Liner	...	Dry-Pre-finished-Transition Fit
Outside Dia. of Production Liner	...	3.6895/3.6905 inch (93.71/93.74 mm)
Outside Dia. of Service Liner	...	3.6875/3.6885 inch (93.66/93.69 mm)
Interference Fit of Production Liner in Block	...	0.001/0.003 inch (0.025/0.076 mm)
Transition Fit of Service Liner in Block	...	0.001/ 0.001 inch (0.025/0.025 mm) or Interference Fit of 0.001 inch
Inside Dia. of Finished Liner in Block	...	3.6015/3.6025 inch (91.48/91.50 mm)
Outside Dia. of Liner Flange	...	3.803/3.808 inch (96.60/96.72 mm)
Flange Thickness	...	0.148/0.150 inch (3.76/3.81 mm)
Depth of Liner Flange relative to Top Face of Cylinder Block	...	+0.002 to - 0.004 inch (+0.05/-0.10 mm.)

NOTE: *Reboring to oversize is not recommended*

Piston :

Type	...	Alfin Piston with Re-entrant bowl. Offset of re-entrant bowl on piston crown should be towards fuel pump side while assembly. An arrow (or) 'F' mark is stamped on top surface of piston for identification
Piston Height in relation to Cylinder Block Top Face	...	0.005 - 0.002 inch (0.150 / 0.060 mm) Above block surface
Bore Dia. for Gudgeon Pin	...	1.2503 / 1.2501 inch (31.758 / 31.753 mm)
Top Ring Groove Width	...	0.118 inch (3.0 mm) – Nominal width
2nd Ring Groove Width	...	0.080 / 0.815 inch (2.05 / 2.03 mm)
3rd Ring Groove Width	...	0.159 / 0.158 inch (4.05 / 4.03 mm)

Ring Gaps

The ring gaps quoted below are for a bore diameter of 3.6015 inch (91.48 mm). When checking ring gaps in a worn bore, 0.003 inch (0.076 mm) should be added to these ring gaps for every 0.001 inch (0.025 mm) increase in bore diameter.

Piston Rings

Top Compression	...	Chromium inlaid, Half Keystone ('Top' marked)
2nd Compression	...	Cast Iron, Taper land ('Top' marked)
3rd Oil Control	...	Conformable oil control ring
Top Ring width	...	0.118 inch (3.0 mm) – Nominal
2nd Ring width	...	0.078 / 0.077 inch (1.99 / 1.97 mm)
3rd Ring width	...	0.157 / 0.156 inch (3.99 / 3.97 mm)

Ring Clearance in Piston Groove

Top ring clearance in Groove	...	Nil (since keystone)
2nd and 3rd ring clearance in Groove	...	0.00315 / 0.00157 inch (0.08 / 0.04 mm)

Ring Gaps

Ring Gap - Top	...	0.0216 / 0.0118 inch (0.55 / 0.30 mm)
Ring Gap - 2nd	...	0.0394 / 0.0315 inch (1.0 / 0.8 mm)
Ring Gap - 3rd	...	0.0216 / 0.0118 inch (0.55 / 0.30 mm)

NOTE: *The ring gaps given above are for when checking in the unworn portion of the cylinder bore.*

Gudgeon Pin

Type	...	Fully Floating
Outside Dia. of Gudgeon Pin	...	1.24975 / 1.250 inch (31.744 mm / 31.750 mm)
Fit in Piston Boss	...	Transition
Clearance Fit in Small End Bush	...	0.0005 / 0.0017 inch (0.0127 / 0.0441 mm)

Small End Bush

Type	...	Steel Backed, Lead Bronze Lined
Outside Dia.	...	1.3785 / 1.3800 inch (35.01 / 35.05 mm)
Length	...	1.04 / 1.058 inch (26.42 / 26.87 mm)
Inside Dia. after Reaming	...	1.2505 / 1.2515 inch (31.76 / 31.79 mm)

Connecting Rod

Type	...	"H" Section
Big End Parent Bore Dia.	...	2.3950/2.3955 inch (60.83/60.85 mm)
Small End Parent Bore Dia.	...	1.37478/1.37620 inch (34.92/34.96 mm)
Big End Width	...	1.5502/1.5525 inch (39.38/39.43 mm)
Big End Side Clearance on Crankpin	...	0.009 / 0.015 inch (0.236 / 0.375 mm)
Length Between Bore Centers	...	8.813 / 8.890 inch (223.85 / 223.82 mm)

NOTE: *The numbered side on connecting rod and cap should be on the fuel injection pump side.*

Connecting Rod Alignment

Large and small end bores must be square and parallel to each other within the limits of ± 0.010 inch (0,25 mm), measured 5 inch (127 mm) each side of the axis of the rod on test mandrel as shown in Fig. B1. With the small end bush fitted, the limit of ± 0.010 inch (0,25 mm) is reduced to ± 0.0025 inch (0,06 mm)

NOTE : *Connecting rod nuts should be replaced whenever the big ends are disturbed.*

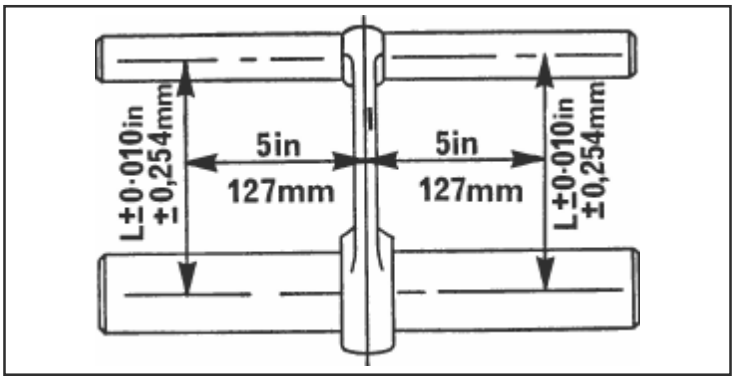


Fig. B1 Connecting Rod

Connecting Rod Bearings

Type	...	Pre-finished, Steel Backed, Aluminium Tin/Copper Lead
Inside Dia.	...	2.252/2.2525 inch (57.19/57.21 mm)
Bearing Running Clearance	...	0.0025/0.0040 inch (0.06/0.10 mm)

Crankshaft (Ref. Fig. H1)

Main Journal Dia. **(Std.)**	...	2.7485/2.7493 inch (69.81/69.83 mm)
Main Journal Length - Number 2 and 3	...	1.2147/1.2227 inch (30.85/31.06 mm)
Main Journal Length-Rear	...	1.8427/1.8457 inch (46.80/46.88 mm)
Main Journal Fillet Radii **(Except Last Main Journal)**	...	0.125/0.140 inch (3.175/3.556 mm)
Last Main Journal Fillet Radius	...	0.1562/0.1662 inch (3.97/4.22 mm)
Crankpin Dia. **(Std.)**	...	2.2484/2.2492 inch (57.11/57.13 mm)
Crankpin Length	...	1.562/1.570 inch (39.67/39.88 mm)
Crankpin Fillet Radii	...	0.172/0.155 inch (4.37/3.96mm)
Surface Finish-All Pins and Journals	...	16 micro inches (0.4 microns) Maximum
Crankshaft End Float	...	0.002/0.015 inch (0.05/0.38 mm)
Crankshaft rear end Seal	...	Lip type
Regrind Undersizes-Main Journals and Pins	...	0.010 inch (0.25 mm), 0.020 inch (0.51 mm), 0.030 inch (0,76 mm)

NOTE : when regrinding, the crank pin length should not exceed 1.575 inch (40,00 mm) and the rear main journal (Crankshaft with lip type rear oil seal) length should not exceed 1.861 inch (47,27 mm) and Nos. 2 and 3 main Journals Width should not exceed 1.2275 inch (31,1785 mm) maximum. ***The maximum permissible UNDERSIZE is 0.030 inch (0,76 mm).***

Crankshaft Thrust Washers

Type	...	...	Steel Backed, Aluminium Tin
Position in Engine	...	..	Cylinder Block, Rear Main Bearing Housing
Thrust Washer Thickness – **Standard**	...	...	0.121/0.123 inch (3.07/3.12 mm)
Thrust Washer Thickness – **Oversize**	...	...	0.1285/0.1305 inch (3.26/3.31 mm)

Main Bearings

Type	...	...	Prefinished Steel Backed, Aluminium Tin/ Copper Lead
Inside Dia. (Fitted)	...	...	2.752/2.7535 inch (69.90/69.94 mm)
Main Bearing Running Clearance	...	...	0.0027/0.005 inch (0.07/0.13 mm)

Camshaft

No. 1 Journal Dia.	...	...	1.869/1.870 inch (47.47/47.50 mm)
Running Clearance	...	...	0.004/0.008 inch (0.10/0.20 mm)
No. 2 Journal Dia.	...	...	1.859/1.860 inch (47.22/47.24 mm)
Running Clearance	...	...	0.004/0.008 inch (0.10/0.20 mm)
No. 3 Journal dia.	...	...	1.839/1.840 inch (46.71/46.74 mm)
Running Clearance	...	...	0.004/0.008 inch (0.10/0.20 mm).
Cam Lift	...	...	0.311/0.314 inch (7.90/7.98 mm)
Gear-Spigot Dia.	...	...	1.9985/1.9995 inch (50.76/50.79 mm)
Oil ways for Rocker Shaft Lubrication	...	...	No. 2 Cam Journal

Cylinder Head

Depth	...	...	2.985/3.015 inch (75.82/76.58 mm)
Leak Test Pressure	...	...	30 lbf/in^2 (2.11 kgf/cm^2)
Valve Seat Angle	...	...	36°
Tappet Bore in Cylinder Head	...	...	0.6245/0.6258 inch (15.86/15.895 mm)
Valve Guide Bore in Cylinder Head	...	...	0.4995/0.5005 inch (12.69/12.71 mm)
Permissable Cylinder Head Bow - Transverse		...	0.003 inch (0.076 mm) maximum
Longitudinal		...	0.006 inch (0.152 mm) maximum
Skimming Allowance on Head Face	...	...	0.012 inch (0.30 mm) maximum Provided nozzle protrusion does not exceed 0.184 inch (4.67 mm) after skimming
Valve layout	...	...	I, E, E, I, I, E

Valve Guides

Inside Dia.	...	...	0.3148/0.3158 inch (7.99/8.02 mm)
Outside Dia.	...	...	0.5018/0.5013 inch (12.74/12.73 mm)
Overall Length	...	...	2.2188 inch (56.36 mm)
Guide Protrusion above Spring Seating Face		...	0.362/0.376 inch (9.19/9.55 mm)
Interference fit of guide in head	...	...	0.0016/0.0031 inch (0.04/0.08 mm)

NOTE: *Valve stem seal (with metal insert) is fitted in both inlet and exhaust valves.*

Inlet Valve

Valve Stem Dia.	...	...	0.311/0.312 inch (7.90/7.92 mm)
Clearance Fit of Valve in Guide	...	...	0.0028/0.0048 inch (0.071/0.12 mm)
Valve Face Angle	...	...	35°
Valve Depth below Cylinder Head Face (Inlet)	...	...	0.050/0.062 inch (1.27/1.57 mm) Not to exceed 0.072 inch (1.83 mm) after regrinding

Exhaust Valve

Valve Stem Dia.	...	...	0.311/0.312 inch (7.90/7.92 mm)
Clearance Fit of Valve in Guide	...	...	0.0028/0.0048 inch (0.071/0.12 mm)
Valve Face Angle	...	...	35°
Valve Depth below Cylinder Head Face (Exhaust)	...	...	0.061/0.074 inch (1.54/1.88 mm) Not to exceed 0.083 inch (2.11 mm) after regrinding

Valve Spring

Free Length	...	...	1.783/1.803 inch (45.29/45.80 mm)
Fitted Length	...	...	1.500 inch (38.10 mm)
Load at Fitted Length	...	...	22.75 lbs ± 2lbs (10.34 kg ± 0.90 kg)

Tappet

Outside Dia. of Shank	...	...	0.6222/0.6237 inch (15.80/15.84 mm)
Clearance fit in Cylinder Head	...	...	0.00075/0.00350 inch (0.02/0.09 mm)

Rocker Shaft

Outside Dia.	...	...	0.6223/0.6238 inch (15.806/15.845 mm)

Rocker Levers

Bush Bore Dia.	...	...	0.6245/0.6258 inch (15.86/15.89 mm)
Clearance Fit on Rocker Shaft	...	...	0.0007/0.0035 inch (0.017/0.088 mm)

Camshaft Gear

No. of Teeth	...	...	50
Gear Bore Dia.	...	...	1.9995/2.0010 inch (50.79/50.82 mm)
Clearance Fit of Gear on Spigot	...	...	0.0000/0.0025 inch (0.00/0.06 mm)

Idler Gear and Hub

No. of Teeth	...	...	90
Bore Dia of Gear	...	...	2.1250/2.1266 inch (53.98/54.02 mm)
Dia. of Hub	...	...	2.1230/2.1238 inch (53.92/53.94 mm)
Clearance of Gear on Hub	...	...	0.0012/0.0036 inch (0.03/0.09 mm)
Gear Hub Width	...	...	1.3175/1.3225 inch (33.46/33.59 mm)
Length of Hub	...	...	1.3275/1.3325 inch (33.72/33.85 mm)
Gear End Float	...	...	0.005/0.015 inch (0.13/0.38 mm)

Crankshaft Gear

No. of Teeth	...	...	25
Dia. of Bore	...	...	1.4995/1.5010 inch (38.09/38.13 mm)
Spigot Dia. of Crankshaft	...	...	1.5000/1.5005 inch (38.10/38.11 mm)
Transition Fit of Gear on Crankshaft	...	...	0.001/0.001 inch (0.025/0.025 mm)

Fuel Pump Gear

No. of Teeth	...	...	50
Dia. of Bore	...	...	1.750/1.751 inch (44.45/44.47 mm)
Pump Adaptor dia.	...	...	1.7407/1.7477 inch (44.21/44.39 mm)
Clearance fit of gear on spigot	...	...	0.0023/0.0103 inch (0.058/0.26 mm)

Timing Gear Backlash

All Gears	...	...	0.003 inch (0.08 mm) minimum

Lubricating Oil Pump Idler Gear

Inside Dia. of Gear Bore	...	...	0.750/0.751 inch (19.05/19.08 mm)
Outside Dia. of Bush	...	...	0.752/0.7535 inch (19.10/19.14 mm)
Interference Fit of Bush in Gear	...	...	0.0010/0.0035 inch (0.025/0.09 mm)
Inside Dia. of Bush-Fitted	...	...	0.6562/0.6572 inch (16.67/16.69 mm)
Dia. of Gear Shaft	...	...	0.6548/0.6553 inch (16.63/16.64 mm)
Running Clearance of Gear on Shaft	...	...	0.0009/0.0024 inch (0.02/0.061 mm)
Gear End Float	...	...	0.008/0.023 inch (0.20/0.58 mm)

Lubricating Oil Pump Drive Gear

Internal Dia. of Gear Bore	...	...	0.4962/0.4972 inch (12.60/12.63 mm)
Pump Drive Shaft Dia.	...	...	0.4990/0.4995 inch (12.67/12.69 mm)
Interference Fit of Gear on Shaft	...	...	0.0018/0.0033 inch (0.045/0.08 mm)

Lubricating Oil Pump Clearances

Type	...	...	Rotor
Inner Rotor to Outer Rotor	...	...	0.0005/0.0025 inch (0.01/0.06 mm)
Inner Rotor end Clearance	...	...	0.0015/0.003 inch (0.038/0.076 mm)
Outer Rotor end Clearance	...	...	0.0005/0.0025 inch (0.01/0.06 mm)
Outer Rotor to Pump Body	...	...	0.011/0.013 inch (0.28/0.33 mm)

Lubricating Oil Relief Valve

Type	...	...	Spring Loaded Plunger
Pressure Setting	...	...	50/65 psi (3.52/4.57 kgf/cm^2)

Lubricating System

Lubricating Oil Pressure	...	...	30/60 psi (2.1/4.2 kgf/cm^2) at maximum engine speed and normal working temperature

Lubricating Oil Filter

Type of Filter	...	...	Full Flow
Element Type	...	...	Canister
By-pass Setting	...	...	13.0/17.0 psi (0.91/1.20 kgf/cm^2)

Lubricating Oil Sump

Capacity	...	...	5.5 Lts (1.452 gal). max. Fill to “FULL” mark on dipstick However the sump capacity vary according to application.

Cooling System

Type	...	...	Thermo Syphon-Pump Assisted
Coolant Capacity-Engine Only	...	...	4.8 litres (1.268 gal) (approx.)

Thermostat

Type	...	...	Wax/Bellows
Opening Temperature	...	...	75° ± 2°C (167°F ± 35.6 °F)
Fully Open Temperature	...	...	89° ± 2°C (192°F ± 35.6 °F)

} or Blanking Sleeve

Water Pump

Type	...	...	Centrifugal
Pulley Bore Dia.	...	...	0.6239/0.6247 inch (15.85/15.87 mm)
Shaft Dia.	...	...	0.6262/0.6267 inch (15.91/15.92 mm)
Interference Fit of Pulley on Shaft	...	...	0.0015/0.0028 inch (0.038/0.07 mm)
Impeller Bore Dia.	...	...	0.6250/0.6257 inch (15.88/15.89 mm)
Shaft Dia.	...	...	0.6262/0.6267 inch (15.91/15.92 mm)
Interference Fit of Impeller on shaft	...	...	0.0005/0.0017 inch (0.01/0.04 mm)
Clearance between Impeller Blade and Body	...	...	0.010/0.020 inch (0.25/0.51 mm)
Distance between impeller Rear face to Pulley face	...		5.531 inch (140.9 mm)

Fuel System

Fuel Oil Specification	...	...	Fuel oil should conform to IS:1460/2000 grade-special or Grade A
Fuel Filter Type	...	...	MICO Duel filter, 0.5 litre (0.132 gal) capacity, Spin on type (primary and secondary)
Fuel Overflow Valve Type	...	...	MICO spring loaded valve
Overflow Valve Location	...	...	FIP fuel gallery (or) Fuel Filter
Fuel Feed Pump	...	...	Plunger type, Flange mounted on Fuel injection pump and driven by FIP Camshaft

Fuel Injection Pump

Make	...	...	Mico, India
Type	...	...	Inline
Mounting	...	...	Flanged mounted
Pump Rotation	...	...	Clockwise (from drive end)
Drive	...	...	Gear
Governor	...	...	Mechanical RSV
Injection Timing (Spill Timing)	...	...	14°+/-1° B.T.D.C.

Alternator

Make	...	...	LUCAS-TVS, India
Type	...	...	A115
System Voltage	...	...	12
Polarity	...	...	Negative earth
Rotation	...	...	Clockwise
Max. Output current	...	...	36 amps

Starter Motor

Make	...	...	LUCAS-TVS, India
Type	...	...	3SM 114
System Voltage	...	...	12
Rotation	...	...	Clockwise
No. of Teeth on Pinion	...	...	10 or 11
Starter Cable Resistance	...	...	0.0017 ohms maximum

NOTE: *The above electrical data is general and can vary with individual applications*

Cold Starting Aid

Device	...	...	Thermostart
Voltage	...	...	12 Volts
Location	...	...	Induction manifold
Height of reservoir above center of Thermostart		...	(4.5 - 10 inch) 114.3 -254 mm

Section C
Operating and Maintenance

Preparation for Starting

Check the radiator coolant level.

Check the engine sump oil level.

See that there is fuel oil in the tank

Check that the starter battery is fully charged and that all electrical connections are properly made and all circuits in order.

Starting the Engine

If the engine is warm, turn starter switch in a clockwise direction to the position number 4 (see Fig. C.1.)

As soon as the engine starts, release the switch to the position number 2.

Be sure that the starter pinion and engine have stopped rotating before re-engaging the starter motor. Otherwise damage may result.

If weather is cold, turn starter switch to the position number 3 (see Fig. C.1) and hold it there for fifteen to twenty seconds.

Then turn the starter switch to the "HS" position, thereby engaging the starter motor.

If the engine does not start after twenty seconds, return the switch to the position number 3 for ten seconds and then re-engage the starter motor by switching to the position number 4.

As soon as the engine starts, release the switch to the position number 2 .

Starting the Engine (Alternative Method)

With some engines, a different starter switch may be found and the cold start aid operated by means of a separate push button switch.

The cold starting procedure is however the same, i.e.

Switch on by turning the starter switch in a clockwise direction to the first position

Press the heater button for fifteen to twenty seconds and then, with the heater button still pressed, turn the starter switch in a further clockwise direction to engage the starter motor. As soon as the engine starts, release both starter switch and heater button.

Cold Starting Aid

Referring to Fig. C.2 the cold start unit comprises a tubular valve body carried in a holder which screws into the inlet manifold, and surrounded by a heater coil, an extension of which forms an igniter coil. The valve body houses a needle, the stem of which holds a ball valve in position against its seating. The whole is surrounded by an open perforated shield. Fuel oil from the container enters through an adaptor.

When the unit is cold, the ball valve is held closed. On switching on the coil, the valve body is heated and expands, opening the ball valve and permitting the entry of fuel. The fuel is vapourised by the heat of the valve body and when the engine is cranked and air is drawn into the manifold, the vapour is ignited by the coil extension and continues to burn, thus heating the inlet air.

1. Off Position

2. ON / Accessories

3. Preheat

4. Start Position

Fig C.1 – Combination Switch

To Stop the Engine

A spring loaded stop control is located near the engine controls and functions by cutting off the fuel at the fuel injection pump.

To operate, pull the knob and hold in this position until the engine ceases to rotate. Ensure that the control returns to the run position, other- wise difficulty may be experienced in restarting the engine.

Turn start switch to the Off position.

Things to Note

Always be sure that the starter pinion has stopped revolving before re-engaging the starter, otherwise the ring or pinion may be damaged.

Ensure that the electrical connection to the cold starting aid is correctly made.

Always ensure that, if a reservoir is used to feed fuel to the starting aid, it is fully primed and is not leaking (Fig. C.3). On later engines, the starting aid fuel feed is taken directly from the fuel filter.

When the coil is switched off, the flow of air in the manifold cools the valve body rapidly and the valve closes.

The cold start aid is a sealed unit and cannot be dismantled. If the unit ceases to function, it must be renewed.

In the event of difficult starting, check that fuel is reaching the cold starting aid in the induction manifold by unscrewing the inlet fuel connection. If fuel is reaching it satisfactorily, then it may be that the cold starting aid itself is not working correctly. This can be checked by removing the air cleaner and watching the cold starting aid when the equipment is used. When the starting switch is turned to the "heat" position, the element should become red hot, and on engagement of the starter motor, it should ignite into flames.

S325.3 engines are fitted with efficient cold starting equipment and no responsibility can be accepted for any damage caused by unauthorised starting aids.

Running-in Procedure

It is not necessary to gradually run-in a new engine and any prolonged light load running during the early life of the engine and in fact prove harmful to the bedding in of piston rings and liners.

Full load can be applied on a new engine as soon as the engine is used, provided that the engine coolant is first allowed to reach a temperature of at least 140° F (60° C).

PREVENTIVE MAINTENANCE

Keep Engine Clean

DAILY OR EVERY 8 HOURS WHICHEVER OCCURS FIRST:

Check level of coolant.

Check level of oil in sump.

Check oil pressure (where gauge fitted).

In extreme dusty conditions, clean air- cleaner regularly.

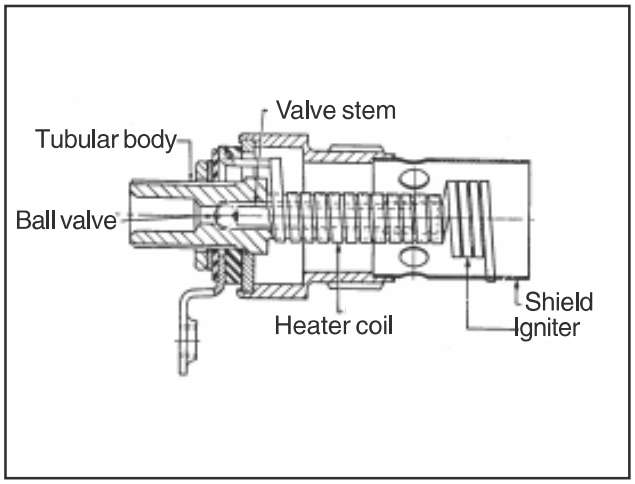


Fig. C2 Thermostart

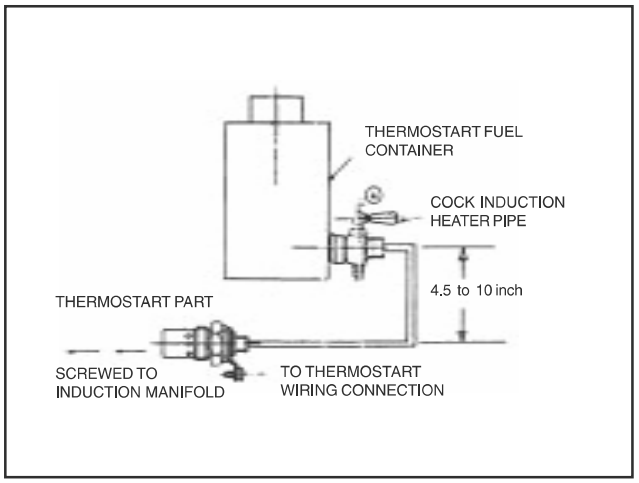


Fig. C3 Typical Layout of Cold Start Device

EVERY 250 HOURS:

Drain and renew lubricating oil. Refer to list of Approved lubricating Oils in Sec. Q page 64.

Renew lubricating oil filter element or canister

Check drive belt tension.

Clean oil bath air cleaner and renew oil.

Clean lift pump pre-filter (where fitted).

Check engine for leakage of oil and coolant

Lubricate alternator rear bush (where fitted).

EVERY 500 HOURS.

Check hoses and clips.

Check atomisers.

Examine valve springs and check tappet clearances.

Inspect valve rocker shaft assembly for lubrication.

Clean and treat battery terminals.

EVERY 1,000 HOURS:

Drain fuel tank, remove and clean.

Flush radiator with clean coolant.

Inspect commutator and brushes of dynamo (if applicable).

NOTE: *The time for cleaning the air cleaner depends on operating conditions; therefore under extremely dusty conditions, the time limit recommended above for cleaning should be decreased.*

The correct maintenance of the air cleaner will greatly assist in reducing bore wear, thereby extending the life of the engine.

FUEL FILTERS MAINTENANCE

Do not clean filter inserts.

Drain filter bowls after every 125 hrs. of operation by loosening sludge screws (wherever provided), until clean fuel flows out.

0.5 LITRE DUAL FILTERS (Spin on type)

Replace first stage filter (primary) after every 500 hrs.

Replace second stage filter (secondary) after every 750 hrs.

FUEL INJECTION PUMP MAINTENANCE

(a) Check the oil level every 125 hrs. Drain off excess oil.

Top up fresh engine oil if the level is low.

Replace oil every 2500 hrs.

(b) Clean air breather every 125 hrs. (if provided)

(c) Clean nylon sleeve every 125 hrs. Clean hollow screw with sleeve every 50 hrs. (wherever provided).

Operators of S 325.3 engines are reminded that the above Preventive Maintenance are general in application: therefore the operator should compare the routine maintenance for his engine with the schedules specified by the manufacturer of the application to which the engine is fitted and where necessary adopt the shorter periods.

while we have given specific periods for preventive maintenance, you should have due regard for the local regulations concerning your machine and ensure that the engine is operating within those regulations.

Post-Delivery Checkover

After a customer has taken delivery of their diesel engine, it is advisable, in their own interest that a general checkover of the engine be carried out after the **first 25 hours** in service.

It is also recommended that the following procedure be adopted where an engine has been out of service for a considerable period before it is again put into service.

The checkover should comprise the following points:-

1. Drain lubricating oil sump and re-fill up to the full mark on the dipstick with new clean oil (Do not overfill).
2. Renew the lubricating oil filter (Spin on type).
3. Check external nuts for tightness.
4. Check and adjust tappet clearances 0.012 in (0.30 mm) cold.
5. Check fuel pipes from tank to fuel injection pump for leaks.
6. Check for lubricating oil leaks and rectify if necessary.
7. Check hose clamps for tightness.

8. Check cooling system for leaks and inspect radiator coolant level.
9. Check fan belt for tension.
10. Carry out test to check general performance of engine.
11. Check engine mounting bolts for tightness.

It is assumed that electrical equipment will have already been checked for such points as rate of charge, effectiveness of connections and circuits, etc.

Thereafter maintenance periods should be in accordance with the instructions given.

Preservation of stored Engines

Where an application which is powered by S 325.3 engine is to be stored for several months it is advisable that some measure of protection be afforded to the engine to ensure that it suffers no ill effects during the intervening period before operations are recommenced.

It is recommended, therefore, that the following procedure be adopted and applied immediately when the unit removed from service:

1. Thoroughly clean all external parts of the engine.
2. Run the engine until it reaches operating temperature. Stop the engine and drain lubricating oil from sump.
3. Drain coolant from radiator and engine cylinder block.
4. Clean out engine breather.
5. After replacing filters fill sump to correct level with clean, new lubricating oil or with a suitable preservative fluid.
6. Remove atomisers and spray into cylinder bores 150 ml of lubricating oil divided between the cylinders.
7. Turn engine slowly over compressions and replace atomisers.
8. Remove air cleaner and any intake pipe which may be fitted between the air cleaner and air intake. Carefully seal air intake orifice with waterproof adhesive tape or some other suitable medium.
9. Remove exhaust pipe and seal opening in manifold as in '8'.
10. Disconnect battery and store in fully charged condition. Before storing the battery, terminals should be treated to prevent corrosion.

The fuel system may either be drained and charged with a suitable preservative designed for the prevailing climatic conditions or alternatively, it may be left primed with normal fuel oil.

Where the latter course is taken it should be noted that deterioration of the fuel oil may occur during the months the fuel system is idle.

If this occurs, the fuel oil may become contaminated with a wax-like substance which will quickly clog the fuel filtering arrangement once the engine is returned to service.

Therefore, before commencing operations in respect of a unit primed with normal fuel oil which has been idle for several months it is recommended that the fuel tank be drained and the interior of the tank thoroughly cleaned. The fuel oil drained off should be discarded as unfit for further use.

Fuel oil contained in the remainder of the fuel system should also be dispelled and the final fuel filter renewed, following which the system may then be recharged with fresh clean fuel oil.

Before starting, the engine should be cranked over by the starter motor with the stop control in the 'off' position until oil pressure is recorded or the oil warning light is extinguished. Do not rapidly accelerate the engine after initial start, allow it to run at slow speed for approximately two minutes to ensure good oil circulation before accelerating to higher speeds.

NOTE : *Where a preservative is used in the lubricating oil sump, this should be drained off and replaced by normal lubricant prior to restarting the engine at the end of the storage period. In the case of a preservative being utilised to charge the fuel system, this need not necessarily be drained off before returning the engine to service. Therefore, where a preservative is used in this respect, the relevant manufacturers of the fluid should be contacted seeking their guidance as to whether their product should be drained away prior to restarting the engine.*

Frost Precautions

Precautions against damage by frost should be taken if the engine is to be left exposed to inclement weather either by adequately draining the coolant system or where this is not convenient an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used.

Should it be the policy to protect engines from frost damage by adding anti-freeze to the cooling system, it is advisable that the manufacturers of the relevant mixture be contacted to ascertain whether their products are suitable for use in S325.3 engines, and also to ensure that their products will have no harmful effect on the cooling system generally. It is our experience that the best results are obtained from anti-freeze which conforms to ***British Standard 3151*** or has been approved by testing in accordance with ***BS 5117, Clause 5,*** to give atleast as good a result as ***BS 3151:1959.***

The coolant solution containing 25 per cent ***anti-freeze manufactured to BS 3151*** in coolant in a properly maintained engine should maintain its anti-freeze and anti-corrosive properties throughout the winter season and in general, ***a safe life of 12 months may be reasonably expected.***

When draining the coolant circulating system it is not enough merely to open the radiator drain tap. The one on the cylinder block must also be opened. This tap is on the rear side of the cylinder block, near the flywheel housing.

Where a pressurised radiator filler cap is fitted, this should be removed before draining the cooling system.

When draining the cooling system ensure that the engine is level.

When the engine is drained, in the majority of applications the water pump is also drained, but rotation of the pump may be prevented by :

(a) Locking of the impeller by ice due to the pump drain hole being blocked by sediment.

(b) The locking of the seal through the freezing of globules of moisture between the seal and the gland.

Operators are therefore advised to take these precautions when operating in temperatures below freezing point:

1. Before starting the engine, turn the fan and water pump by hand: this will indicate if freezing has taken place. If freezing has taken place, this should free any ice formation.

2. If it is impossible to turn the pump by hand, the radiator and engine should be filled with warm coolant.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the manufacturer's instructions before refilling with normal coolant.

If the foregoing action is taken, no harmful effects should be experienced, but the manufacturer cannot be held responsible for any frost damage or corrosion which may be incurred.

SECTION D FAULT FINDING CHART

The following table lists problems and their possible causes with recommended action.

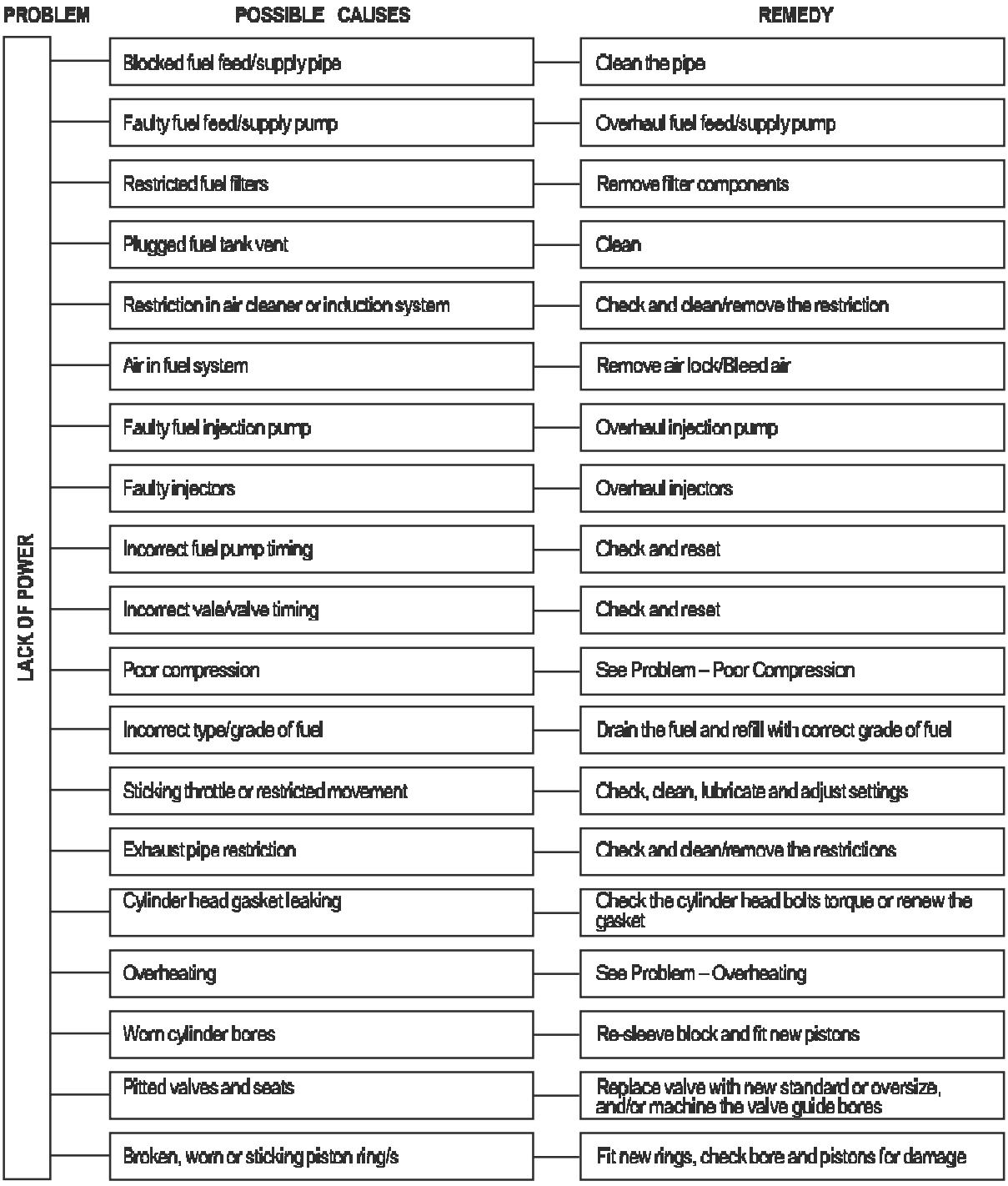
IMPORTANT : *When attending/performing a repair, the cause of the problem must also be investigated and corrected to avoid repeat failures.*

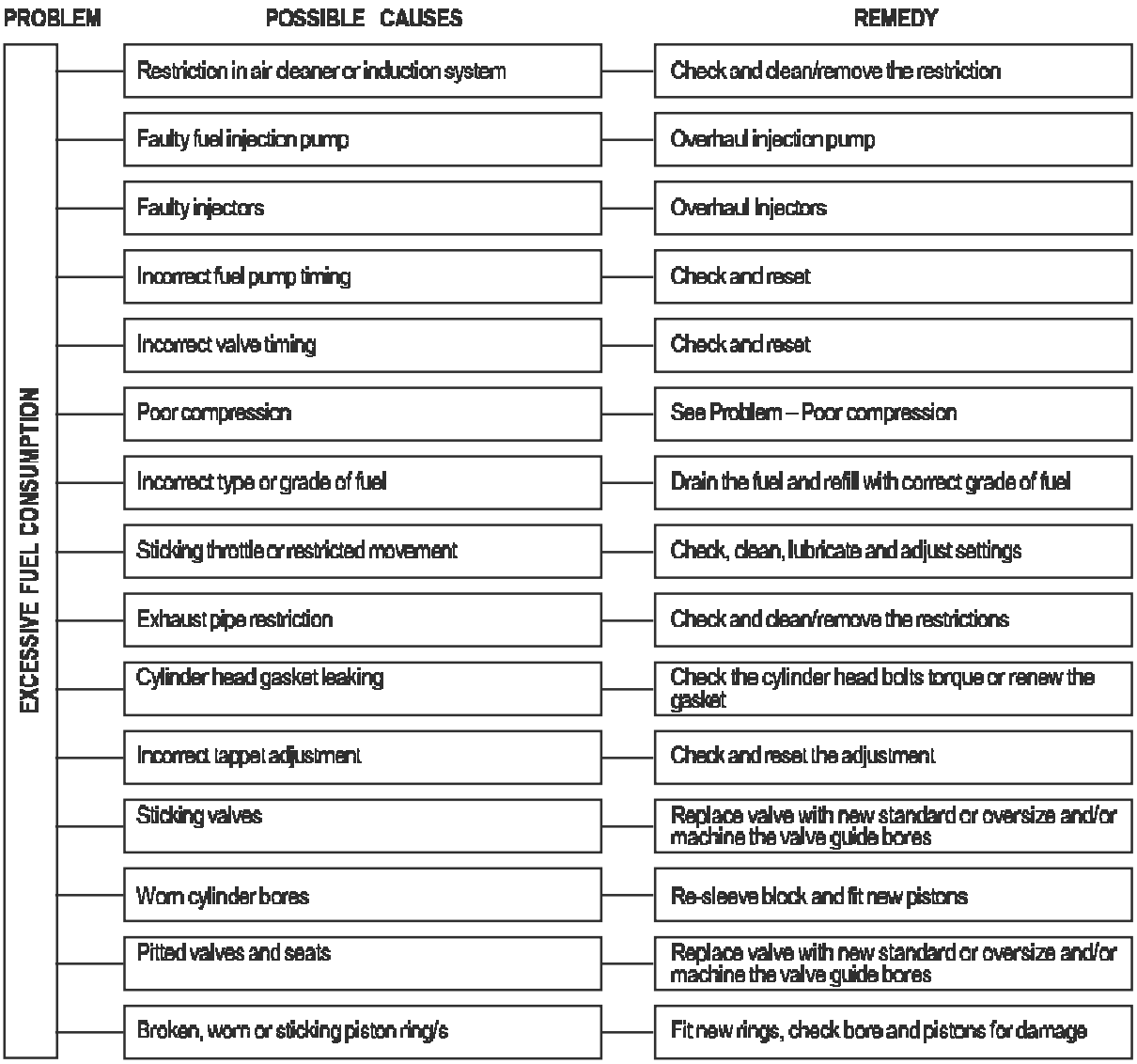
PROBLEM	POSSIBLE CAUSES	REMEDY
LOW CRANKING SPEED	Battery capacity low	Change or renew the battery
	Bad electrical connections	Check the connections or renew electricals
	Faulty starter motor	Overhaul starter motor
	Lubricating Oil of incorrect grade	Drain and refill with specified grade of oil
ENGINE DOES NOT START	Low cranking speed	See Problem – Low Cranking speed
	Fuel tank empty	Fill the tank with fuel
	Incorrect type or grade of fuel	Drain and refill with correct type/grade of fuel
	Faulty stop control operation	Check the stop control cable movement and setting
	Blocked fuel feed/supply pipe	Clean the pipe
	Faulty fuel feed/supply pump	Overhaul fuel feed/supply pump
	Chocked/Plugged fuel filters	Renew filter elements
	Air in fuel system	Remove air lock/Bleed air
	Faulty fuel injection pump	Overhaul injection pump
	Faulty injectors	Overhaul injectors
	Broken fuel injection pump drive	Fit new drive
	Incorrect fuel pump timing	Check and reset
	Incorrect valve timing	Check and reset
	Poor compression	See Problem – Poor Compression
	Worn cylinder bores	Re-sleeve block and fit new pistons
	Pitted valve/s and seat/s	Replace valve with new standard or oversize, and/or machine the valve guide bores
	Broken, worn or sticking piston ring/s	Fit new ring/s, check bore and pistons for damage

PROBLEM	POSSIBLE CAUSES	REMEDY
DIFFICULT STARTING	Low cranking speed	See Problem – Low Cranking Speed
	Faulty stop control operation	Check the stop control cable movement and setting
	Blocked fuel feed/supply pipe	Clean
	Blocked fuel tank vent	Clean
	Incorrect type or grade of fuel	Drain the fuel and refill with correct grade of fuel
	Exhaust pipe restriction	Check and clean/remove the restrictions
	Faulty fuel feed/supply pump	Overhaul fuel feed/supply pump
	Restricted fuel filters	Renew filter elements
	Restriction in air cleaner or induction system	Check and clean/remove the restriction
	Air in fuel system	Remove air lock/Bleed air
	Faulty fuel injection pump	Overhaul injection pump
	Faulty injectors	Overhaul injectors
	Incorrect fuel pump timing	Check and reset
	Incorrect valve timing	Check and reset
	Poor compression	See Problem – Poor Compression
	Sticking valves	Replace valve with new standard or oversize, and/ or machine the valve guide bores
	Worn cylinder bores	Re-sleeve block and fit new pistons
	Pitted valves and seats	Replace valve with new standard or oversize, and/ or machine the valve guide bores
	Broken, worn or sticking piston ring/s	Fit new rings, check bore and pistons for damage

PROBLEM	POSSIBLE CAUSES	REMEDY
MISFIRING	Restricted fuel feed/supply pipe	Clean pipe
	Faulty fuel feed/supply pump	Overhaul fuel feed/supply pump
	Restricted fuel filters	Remove filter elements
	Air in fuel system	Remove air lock/Bleed air
	Faulty fuel injection pump	Overhaul injection pump
	Faulty injectors	Overhaul injectors
	Incorrect fuel pump timing	Check and reset
	Incorrect valve timing	Check and reset
	Poor compression	See Problem – Poor compression
	Cylinder head gasket leaking	Check the cylinder head bolts torque or renew the gasket
	Overheating	See Problem – Overheating
	Incorrect tappet adjustment	Check and reset the adjustment
	Sticking valves	Replace valve with new standard or oversize, and/or machine the valve guide bores
	Incorrect high pressure pipes	Renew the pipes of correct specification
	Pitted valves and seats	Replace valve with new standard or oversize, and/or machine the valve guide bores.

PROBLEM	POSSIBLE CAUSES	REMEDY
EXCESSIVE CRANKCASE PRESSURE	Plugged breather pipe	Clean the pipe
	Cylinder head gasket leaking	Check the cylinder head bolts torque or renew the gasket
	Worn cylinder bores	Re-sleeve block and fit new pistons
	Broken, worn or sticking piston ring/s	Fit new rings, check bore and pistons for damage
	Worn valve stems and guides	Renew valves and guides
	Piston seized inspect the bore for damage	Replace with new pistons assembly and check/
POOR COMPRESSION	Overheating	See Problem – Overheating
	Incorrect valve timing	Reset the timing
	Cylinder head gasket leaking	Check the cylinder head bolts torque or renew the gasket
	Incorrect tappet adjustment	Check and reset the adjustment
	Sticking valves	Replace valve with new standard or oversize and / or machine the valve guide bores
	Worn cylinder bores	Re-sleeve block and fit new pistons
	Pitted valves and seats	Replace valve with new standard or oversize, and/ or machine the valve guide bores
	Broken, worn or sticking piston ring/s	Fit new rings, check bore and piston for damage
	Worn valve stems and guides	Renew valves and guides
	Broken valve springs	Fit new springs


PROBLEM
POSSIBLE CAUSES
REMEDY
LACK OF POWER
Blocked fuel feed/supply pipe
Clean the pipe
Faulty fuel feed/supply pump
Overhaul fuel feed/supply pump
Restricted fuel filters
Remove filter components
Plugged fuel tank vent
Clean
Restriction in air cleaner or induction system
Check and clean/remove the restriction
Air in fuel system
Remove air lock/Bleed air
Faulty fuel injection pump
Overhaul injection pump
Faulty injectors
Overhaul injectors
Incorrect fuel pump timing
Check and reset
Incorrect vale/valve timing
Check and reset
Poor compression
See Problem – Poor Compression
Incorrect type/grade of fuel
Drain the fuel and refill with correct grade of fuel
Sticking throttle or restricted movement
Check, clean, lubricate and adjust settings
Exhaust pipe restriction
Check and clean/remove the restrictions
Cylinder head gasket leaking
Check the cylinder head bolts torque or renew the gasket
Overheating
See Problem – Overheating
Worn cylinder bores
Re-sleeve block and fit new pistons
Pitted valves and seats
Replace valve with new standard or oversize, and/or machine the valve guide bores
Broken, worn or sticking piston ring/s
Fit new rings, check bore and pistons for damage


PROBLEM
POSSIBLE CAUSES
REMEDY
EXCESSIVE FUEL CONSUMPTION
Restriction in air cleaner or induction system
Check and clean/remove the restriction
Faulty fuel injection pump
Overhaul injection pump
Faulty injectors
Overhaul Injectors
Incorrect fuel pump timing
Check and reset
Incorrect valve timing
Check and reset
Poor compression
See Problem – Poor compression
Incorrect type or grade of fuel
Drain the fuel and refill with correct grade of fuel
Sticking throttle or restricted movement
Check, clean, lubricate and adjust settings
Exhaust pipe restriction
Check and clean/remove the restrictions
Cylinder head gasket leaking
Check the cylinder head bolts torque or renew the gasket
Incorrect tappet adjustment
Check and reset the adjustment
Sticking valves
Replace valve with new standard or oversize and/or machine the valve guide bores
Worn cylinder bores
Re-sleeve block and fit new pistons
Pitted valves and seats
Replace valve with new standard or oversize and/or machine the valve guide bores
Broken, worn or sticking piston ring/s
Fit new rings, check bore and pistons for damage

PROBLEM	POSSIBLE CAUSES	REMEDY
BLUE/WHITE SMOKE	Incorrect grade of lubricating oil	Drain and refill with specified grade of oil
	Overfilled air cleaner oil or use of incorrect grade (wet type air cleaner)	Check the oil level and remove as necessary or of oil refill with correct grade oil
	Incorrect fuel pump timing	Check and reset
	Incorrect valve timing	Check and reset
	Poor compression	See Problem – Poor Compression
	Cylinder head gasket leaking	Check the cylinder head bolts torque or renew the gasket
	Incorrect tappet adjustment	Check and reset the adjustment
	Worn cylinder bores	Re-sleeve block and fit new pistons
	Broken, worn or sticking piston ring/s	Fit new rings, check bore and pistons for damage
	Worn valve stems and guides	Renew valves and guides
	Piston seized damage	Replace piston assembly and check the bore for
LOW ENGINE OIL PRESSURE	Incorrect grade of lubricating oil	Drain and refill with specified grade of oil
	Worn or damaged big end bearings	Renew the bearings
	Insufficient oil in sump	Top up as necessary
	Oil gauge faulty	Fit new gauge
	Oil pump worn	Renew oil pump
	Oil pressure relief valve faulty	Fit new relief valve
	Faulty suction pipe	Renew the pipe
	Chocked/Plugged oil filter	Replace with new filter
	Plugged sump strainer	Clean the strainer

PROBLEM	POSSIBLE CAUSES	REMEDY
ENGINE KNOCKS	Faulty fuel feed/supply pump	Overhaul fuel feed/supply pump
	Faulty injectors	Overhaul injectors
	Incorrect fuel pump timing	Check and reset
	Incorrect valve timing	Check and reset
	Incorrect type or grade of fuel	Drain and refill with correct grade of fuel
	Overheating	See Problem – Overheating
	Incorrect tappet adjustment	Check and rest the adjustment
	Sticking valves	Replace valve with new standard or oversize, and / or machine the valve guide bores
	Worn cylinder bores	Re-sleeve block and fit ne pistons
	Broken, worn or sticking piston ring/s	Fit new rings, check bore and pistons for damage
	Overfilled cleaner or use of Incorrect grade of oil (Wet type Air cleaner)	Check the level or drain out and refill with correct grade oil
	Worn or damaged big end bearings	Renew the bearings
	Piston seized damage	Replace piston assembly and check the bore for
	Broken valve spring	Replace new springs

PROBLEM	POSSIBLE CAUSES	REMEDY
VIBRATION	Faulty fuel injection pump	Overhaul injection pump
	Faulty injectors	Overhaul injectors
	Poor compression	See Problem – Poor Compression
	Sticking throttle or restricted movement	Check, clean, lubricate and adjust settings.
	Cylinder head gasket leaking	Check the cylinder head bolts torque or renew the gasket
	Overheating	See Problem – Overheating
	Sticking valves	Replace valve with new standard or oversize, and/or machine the valve guide bores
	Incorrect high pressure pipes	Renew with pipes of correct specifications
	Broken worn or sticking piston ring/s	Fit new rings, check bore and pistons for damage
	Piston seized damage	Replace piston assembly and check the bore for
	Faulty engine mounting	Check and redo the installation of engine
	Incorrectly aligned flywheel housing or flywheel	Check and align flywheel housing and flywheel
HIGH OIL PRESSURE	Incorrect grade of lubricating oil	Drain and refill with specified grade of oil
	Inaccurate relief gauge	Check and renew gauge
	Pressure relief valve faulty	Fit new relief valve
STARTS & STOPS	Restriction Plugged fuel filter	Fit new filter
	Restriction in air cleaner or induction system	Remove the restriction
	Air in fuel system	Remove the air lock/Bleed air

PROBLEM	POSSIBLE CAUSES	REMEDY
ERRATIC RUNNING	Sticking throttle or restricted movement	Check, clean, lubricate and adjust settings
	Overheating	See Problem – Overheating
	Incorrect tappet adjustment	Check and reset the adjustment
	Sticking valves	Replace valve with new standard or oversize, and/or machine the valve guide bores
	Incorrect high pressure pipes	Renew the pipes of correct specifications
	Broken, worn-out or sticking piston ring/s	Fit new rings, check bore and pistons for damage
	Piston seized	Replace piston assembly and check the bore for damage
	Broken valve spring	Replace with new springs

ERRATIC RUNNING	Faulty stop control operation	Check the stop control cable movement and setting
	Resticted fuel feed/supply pump	Clean
	Faulty fuel feed/supply pump	Overhaul fuel feed/supply pump
	Plugged fuel filters	Chocked fuel filters
	Restriction in air cleaner or induction system	Check and clean/remove the restriction
	Air in fuel system	Remove air/Bleed air lock
	Faulty fuel injection pump	Overhaul injection pump
	Faulty injectors	Overhaul injectors
	Poor compression	Renew piston rings or re-sleeve as necessary
	Plugged fuel tank vent	Clean the vent

PROBLEM	POSSIBLE CAUSES	REMEDY
OVERHEATING	Coolant level too low	Top up as necessary
	Loose fan belt	Tighten the fan belt
	Faulty Temperature gauge	Check and replace
	Restriction in coolant jacket	Remove the restriction by reverse flushing entire cooling system
	Plugged radiator	Clean and check for free flow
	Restriction in air cleaner or induction system	Check and clean/remove the restriction
	Damaged fan	Fit new fan
	Faulty thermostat	Replace with new thermostat
	Faulty water pump	Overhaul or renew the water pump
	Exhaust pipe restriction	Remove the restriction
	Faulty injector	Overhaul Injector
	Incorrect fuel pump timing	Reset the timings
	Incorrect valve timing	Reset valve timings
	Cylinder head gasket leaking	Check the cylinder head bolts torque or renew the gasket
	Faulty fuel injection pump	Overhaul injection pump
	Piston seized damage	Replace piston assembly and check the bore for

Section E
Cylinder Head

The number of hours run has no bearing on when to overhaul the cylinder head because carbon, beyond a superficial coating does not form and accumulate in the combustion chambers and on the pistons as is the case with a gasoline engine.

Ease of starting and performance are the determining factors. Therefore the cylinder head should only be removed when it is absolutely necessary.

To Remove the Cylinder Head

1. Drain coolant from radiator and cylinder block.
2. Detach coolant connections from thermostat housing on front of cylinder head.
3. Remove air cleaner.
4. Detach cold starting equipment connections (if fitted).
5. Remove the oil pipe from the camshaft oil reducer to the cylinder head.
6. Disconnect the exhaust pipe from the engine exhaust manifold.
7. Remove the injection pipes from the fuel pump to atomisers.

WARNING:- Cover the fuel pump delivery ports with suitable protective caps.

8. Remove atomiser leak-off pipes
9. Remove the atomisers. ***In S325.3 engine, only one stud with nut and bracket is being used to retain the atomiser in position on cylinder head.***
10. Remove the cylinder head cover.
11. Disconnect the oil pipe to rocker shaft.
12. Remove the rocker shaft assembly bringing above named oil pipe with it.
13. Remove the cylinder head nuts/setscrews.
14. Remove the cylinder head. Do not insert screwdriver or any other sharp instrument between the cylinder head and block. Place the cylinder head on a flat surface, preferably wood, to avoid damage.

To Remove the Valves

Depress the spring cap, and spring by means of a valve spring compressor and remove the two half conical collets. Remove the spring caps,springs and washers thus freeing the valves for removal. The valves and valve seats should be reconditioned in the normal way, using grinding compound or by means of specialised equipment.

The valve seat angle is 36° and the valve face angle 35°.

Do not forget that the efficiency of a diesel engine depends largely on the maintenance of good compression. Contact between valve and seatings must therefore be the best possible.

Care should be taken to avoid unnecessary grinding away of the seat as the maximum clearance between the valve head and the cylinder head bottom face should not exceed 0.072 inch (1.83 mm) for inlet. The exhaust valve head depth should not exceed 0.083 inch (2.11 mm). This can easily be checked by means of a suitable gauge and feelers.

The valve seats on S325.3 engines, are recessed into the cylinder head and a groove is cut where the proper valve seat ends in the mitred recess in the head. When valves have been reconditioned several times, it is possible that the valve may become masked by sinking too low in the cylinder head and in these circumstances the groove referred to should be re-cut accordingly.

With earlier engines, the valves were numbered and the cylinder head was marked with corresponding numbers.

With current engines the valves and seats are not numbered and where a valve is to be used again, it should be suitably marked to ensure it is replaced in its original position.

Rocker Levers and Bushes

Wash the rocker shaft assembly thoroughly in cleaning solvent.

Examine the rocker bushes for wear. The rockers should be an easy fit on the shaft without excessive side play.

If the rocker bushes are worn, it will be necessary to replace with a new bush and reamed to correct size.

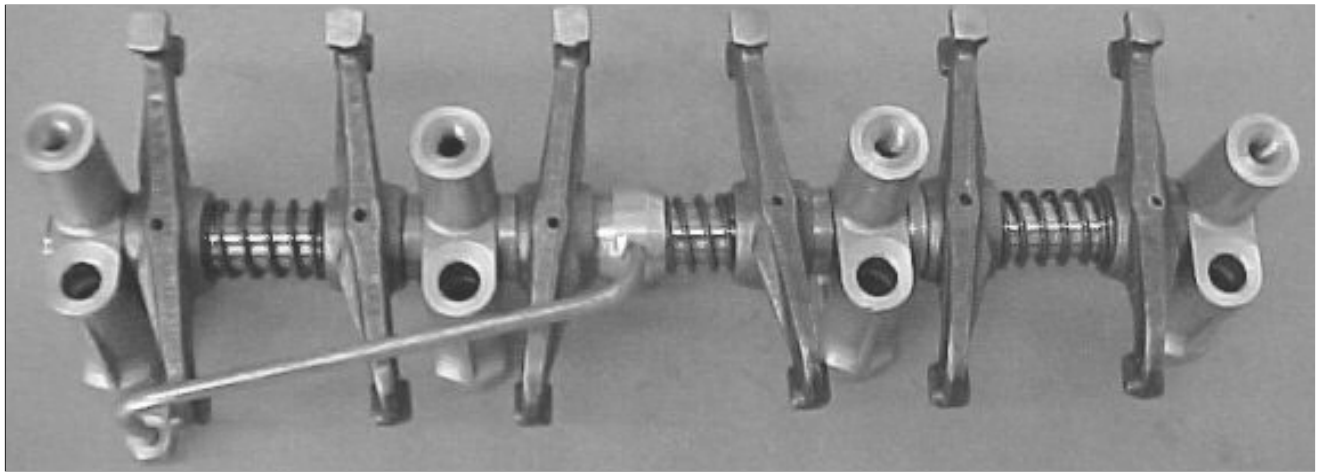


Fig E.1 Rocker Lever Assembly

When dismantling rocker shaft assembly make careful note of the order of assembly of the various parts, supports, spacers, springs and rockers, so that re-assembly may be facilitated and that left and right-hand rockers are correctly placed and opposite of their respective tappets and valves.

Valve Guides

Examine the valve guides for wear, if necessary replace with new guides.

Clean the new guides, removing any burrs.

When pressing in a valve guide, care must be taken to ensure it is installed the correct way. Both ends are chamfered, one at 45°, the other at 20°. The end that is chamfered at 20° is recessed in the bore. This end should be inserted into the cylinder head top face and pulled Into the parent bore until the opposite end (chamfered at 45°) protrudes 0.362/0.376 inch (9.195/9.550 mm) above the top face. Valve stem seal (with metal insert) is fitted over valve guide.

Tappets

The tappets slide in holes bored in the cylinder head. The wear, under normal conditions, is negligible.

The running clearance between the top of the tappet and the rocker should be 0.012 inch (0.30 mm) when the engine is cold.

When adjusting this clearance, tighten tappet locknut effectively, so that it does not loosen in service.

General

All studs on the cylinder head and top face of the cylinder block should be examined for looseness, damaged threads, etc. the cylinder head nuts/setscrews should also be examined to ensure the threads are not damaged.

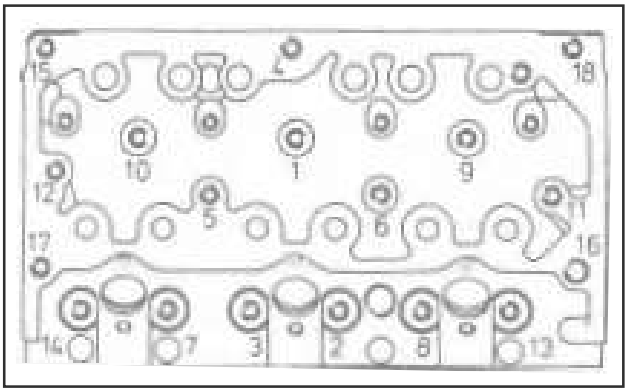


Fig E.2 Cylinder Head Tightening Sequence

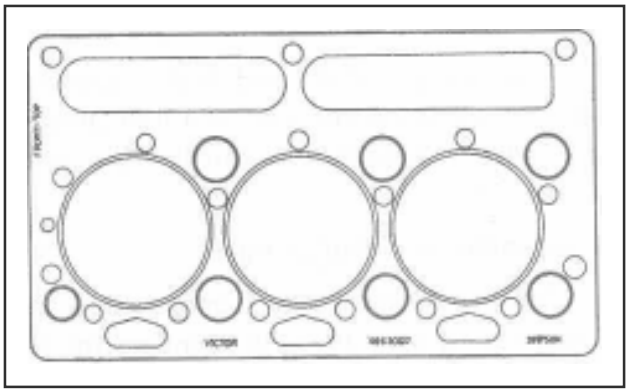


Fig E.3 Cylinder Head Gasket

All joint faces should be examined for pitting and scoring.

Wash out and thoroughly clean the coolant passages in the head subsequently drying out and finally cleaning with compressed air.

If the coolant jacket of the cylinder head shows signs of excessive scale a proprietary brand of descaling solution should be used.

If possible, the cylinder head should be coolant tested for leaks with warm coolant at a coolant pressure of 30 lbf/in^2 (2.11 Kgf/cm^2).

IMPORTANT

The relative valve head depth, however, must afterwards be checked and if necessary corrected to conform with the limits quoted on section B.

Re-assembly and Replacing

Replace valves, washer, spring, collars and collets, taking care that the numbers on the valves correspond to the numbers stamped adjacent to the valve seats. (if Stamped)

On the engines only one spring is fitted to each valve with a spring seating washer.
Before replacing the cylinder head it is extremely important to ensure that the faces of the cylinder block and cylinder head are perfectly clean.

A new cylinder head gasket should be used. The gasket is marked to indicate how it should be fitted **(Marked 'Top Front')** – Ref. Fig. E. 3

Now non-retorque type gasket is being used. It should be fitted dry. This gasket does not require retorquing in Post-Delivery inspection.

When the underface of the cylinder head is perfectly clean, the head may be lowered into position on its studs and the nuts/setscrews pulled down in the order shown in Fig E2. The cylinder head nuts/setscrews should be pulled down to the recommended torque .

Replace atomisers.

Replace the rocker shaft assembly, but before tightening the securing nuts the rockershaft should be set so as to ensure correct lubrication of the assembly. The correct position for the shaft is when the slot in the end of the shaft is set 30° after the horizontal position.

When the rocker shaft is correctly positioned, tighten the securing nuts and set the valve clearance to 0.012 inch (0.30 mm).

Connecting the pipes and make connections as listed under "To remove the Cylinder Head".

Provision is made in the cylinder head coolant outlet for the housing of a thermostat which must be fitted. On no account must the engine be started without a thermostat fitted.

Adjusting Tappet Clearance

The three throw 120° crankshaft makes it necessary to adopt a slightly different sequence for tappet adjustment to the normally accepted procedure for four and six cylinder engines.

Valve clearances for both inlet and exhaust should be set to 0.012 inch (0,30 mm) cold.

To adjust clearances on engines with a flywheel T.D.C. mark proceed as follows:-

Remove the rubber plug in the inspection hole on the flywheel housing.

Rotate the crankshaft until the T.D.C. line on the flywheel is in the center of the inspection hole and No. 1 piston is on compression stroke (both valves fully closed).

NOTE: *In all applications, the T.D.C. marking is given on crankshaft pulley with a pointer on timing case cover.*

Check and adjust clearances as necessary on Nos. 1, 2, 3 and 5 valves.

Turn crankshaft one revolution (360°) and repeat for Nos. 4 and 6 valves (T.D.C. mark visible through inspection hole on flywheel housing or on crank pulley)

Replace rubber plug in flywheel housing.

To adjust clearances without a T.D.C. mark, proceed as follows:-

Turn the crankshaft until the valves of No. 1 cylinder are rocking (inlet valve opening and exhaust valve closing).

In this position, check and adjust clearances, as necessary, on Nos. 4 and 6 valves (No. 1 valve at front of engine).

Temporarily mark the crankshaft pulley and the adjacent point on the timing case cover and turn the crankshaft one complete revolution (360°) until the marks re-align.

In this position, adjust the clearances on Nos. 1, 2, 3 and 5 valves.

Section F
Pistons and Connecting Rods

The pistons are of special light aluminium alloy with a re-entrant bowl in the crown (Fig. F-1). They are secured to the connecting rods by means of fully floating gudgeon pins which work in thin wall steel backed lead bronze lined bushes fitted in the small ends of the connecting rods. Circlips are provided in the pistons to secure the gudgeon pins in position. Three rings are fitted to each piston. All the piston rings are fitted above the gudgeon pin.

The connecting rod big ends are split at right angles to the axis of the rods, the caps being secured by two bolts and nuts.

Always ensure that big end nuts are replaced by new, once they are removed.

The big end bearings are of the thin wall type consisting of a thin steel shell lined with aluminium tin.

To ensure correct replacement, the pistons are marked 1 to 3, number 1 being at the front of the engine. The number can be found stamped on each piston crown.

The connecting rods and caps, are also marked. On one side they are stamped with a number corresponding to their position in the engine.

To Remove Pistons and Connecting Rods

1. Remove cylinder head assembly (Ref. Section E).
2. Remove sump
3. Remove oil pump
4. Turn the engine until number one connecting rod is at bottom center. Remove bolts and nuts securing the connecting rod cap.
5. Remove the connecting rod cap and both top and bottom half bearing shells.
6. The piston and connecting rod can then be pushed out of the top of the cylinder block.
7. Continue operations until all three pistons and connecting rods have been removed.
8. Keep all pistons, connecting rods, caps, bearing shells, bolts and nuts together as separate assemblies, each to each as marked.

To Remove Gudgeon Pins

Remove the circlips from the pistons, using a pair of long nosed pliers.

The gudgeon pins can now be removed and the connecting rods separated from the pistons. If the pins are tight in the pistons, warm the latter in liquid to a temperature 100° to 120°F (38-49°C) which will free the pins.

To Fit New Small End Bushes

The small end bushes are a press fit in the connecting rods.

Press out the old bushes using a suitable press.

Remove any sharp edges around the connecting rod small end parent bores.

Press in the new bushes using a suitable tool, at the same time ensuring that the oil holes in the bushes coincide with the holes in the top of the connecting rods.

Ream out the new bushes in situ to suit their respective gudgeon pins (Section B / Page 9), and check for parallelism and twist. (Section B / Page 10)

To Assemble Pistons and Connecting Rods

If the original pistons are to be used again they should be re-assembled to their respective connecting rods, i.e., the piston stamped No. 1 should be fitted to the connecting rod stamped No. 1.

Pistons for the S 325.3 engine should be fitted with the offset cavity in the crown towards the side of the connecting rod that is marked with the identification number towards FI Pump side.

Assemble the connecting rod to the pistons and insert the gudgeon pin. If the pins are tight in the pistons, warm the pistons in liquid to a temperature of 100° to 120°F. (38° to 49°C) The gudgeon pin can then easily be pushed into position.

Fit the circlips to the piston. It is difficult to advise as to when new circlips should be fitted, but in the event of an engine being in service for a lengthy period it is advisable that new circlips be used, during re-assembly.

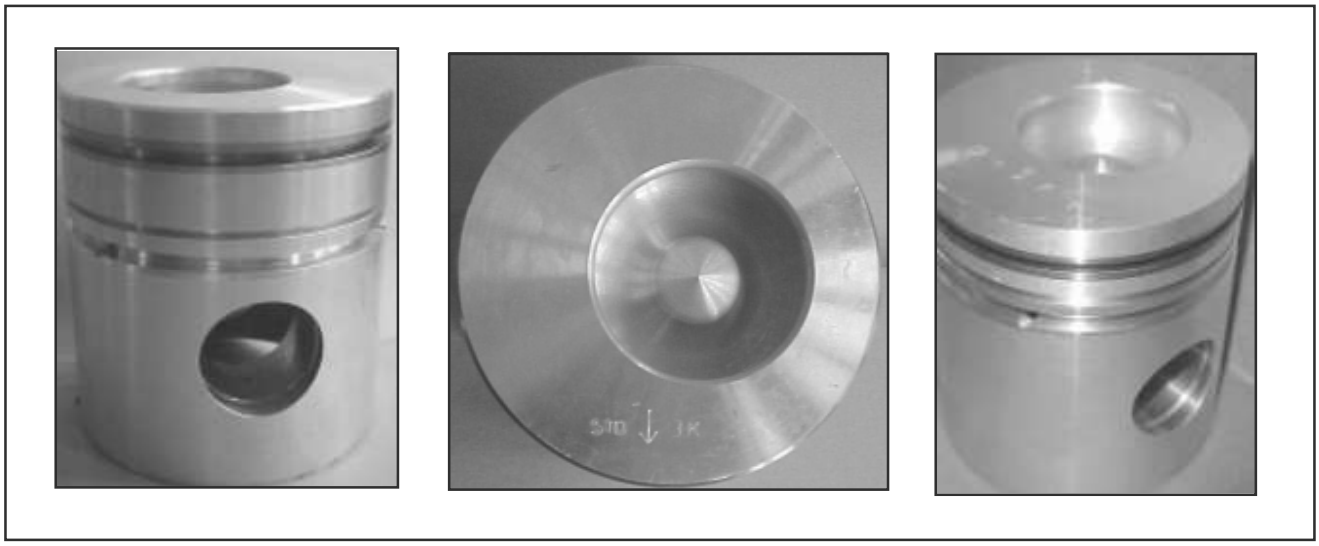


Fig F.1 Piston with re-entrant bowl (ALFIN type)

Fitting New Rings (Ref. Fig. F2)

The piston and rings should be thoroughly washed to remove any oil and grease.

Check piston rings for correct gap (Ref. Section B / Page 9).

In worn cylinder bores, the gaps should be checked at the unworn top of the bore, after any carbon has been removed.

Fit the rings to the piston in the following position (reading from the top of the piston).

1. Ring compression (Chromium inlaid, Half Keystone with 'Top' marked).
2. Ring compression (Cast Iron, Taper land with 'Top' marked).
3. Conformable oil control Ring

When fitting new rings to original pistons clean out the piston ring grooves using the old ring and or a piston ring groove cleaner.

The pistons should be carefully examined for bruising of the ring grooves and to ensure that the rings move truly in their grooves. In addition the piston skirt should be examined and if there is any scoring, the piston must not be used again.

To Fit Conformable oil Ring

1. Fit the helical coil spring onto the 3rd groove of the piston.
2. Insert the latch into the coil spring aligning both the ends.
3. Fit the outer C.I. ring over the coil spring. Ensure coil spring gets seated properly inside the ring groove.
4. Also ensure the coil spring latch is on the opposite side of the ring open end gap.

To Replace Pistons and Connecting Rods

Connecting rods and caps, are plainly marked to indicate their original position in the engine. The numbers are stamped on that side of the connecting rod and cap which is machined to take the locating lips of the big end bearings.

Before fitting pistons, the cylinder bores should be given a liberal coating of clean lubricating oil.

When fitting pistons and connecting rods to the cylinder block and crankshaft, ensure that the side of the connecting rod which is stamped with the number goes to the fuel pump side of the engine.

For S 325.3 engines, ensure that the word "F"/arrow marked on the piston crown is towards the front of the engine.

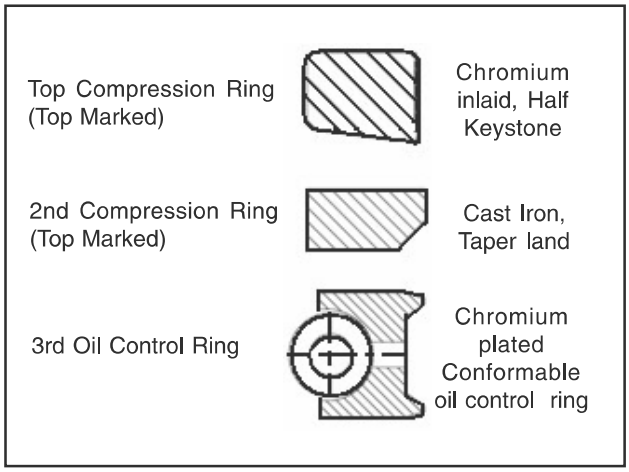


Fig F.2 Ring layout

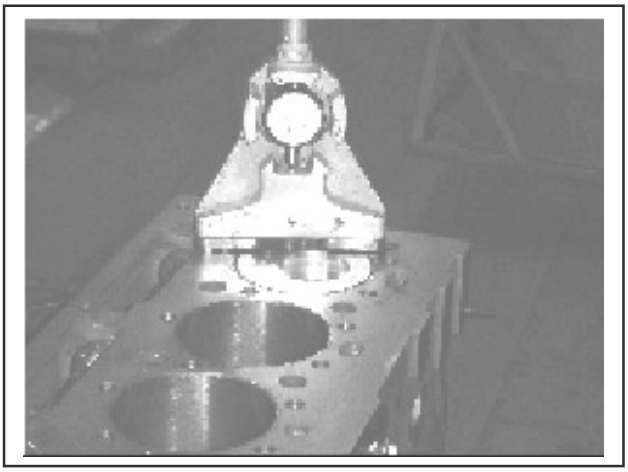


Fig F.3 Checking Piston topping limit

Insert the pistons and connecting rods into the cylinder bores from the top, ensuring the piston and rod stamped No. 1 are fitted into No. 1 bore and No. 2 into No. 2 bore and so on commencing from the front of the engine.

To minimise the possibility of breaking piston rings it is advisable to use a piston guide. Take care not to damage the rings. Should the piston accidently drop partly into the cylinder bore and is held suspended by a piston ring, it must be taken out again and the ring examined to see if it is cracked or broken.

Turn the crankshaft until the appropriate crankpin is at bottom center, pull the connecting rod to the crankpin and insert the half bearing.

Fit the cap and cap half bearing, ensuring that the markings on connecting rod and cap coincide.

The nuts used on the big end bolts should not be used a second time but should be replaced by new whenever they are removed.

Tighten the connecting rod nuts using a torque wrench set to the tension given on Section B / Page 6.

Rotate crankshaft by hand and note that all parts move freely.

Check the piston height in relation to the top face of the cylinder as described below.

Fitting New Pistons

An important point to note is that when the crankpin is at top dead center the crown of the piston must be 0.005 / 0.002 inch (0.150 / 0.060 mm) above block surface.

Pretopped pistons are being used with letter "L" or "H" marked on piston crown for identification

"L" – Low grade / "H" – High grade.

(***NOTE :*** *This grade does not refer to material grade.*)

To determine the piston level, the piston assembly and connecting rod should be fitted to the cylinder block and crankshaft as previously described.

When assembled, turn the crankshaft to bring the piston to T.D.C. and check the distance between the piston crown and the top face of the cylinder block as shown in Fig. F.3.

Carry out this operation with each new piston in turn. If necessary, it has to be replaced by another new piston. The piston should not be machined for any reason in an attempt to correct this height.

The distance between the cylinder block face and piston crown should now be checked to ensure the limit has been maintained when the piston is at Top Dead Center (TDC).

Section G
Cylinder Block and Liners

The cylinder block is fitted with renewable thin wall cast iron dry cylinder liners. The cast iron cylinder liners are an interference fit and require boring and honing to size after fitting.

Cylinder liners fitted to S 325.3 engines cannot be rebored. When they are worn to an extent whereby engine performance is affected, they should be renewed.

To Remove Liners

1. Remove cylinder head as detailed in Section E.
2. Remove the piston and connecting rod assemblies, crankshaft and all component parts of the cylinder block as detailed in the appropriate sections of this manual.
3. Remove cylinder head studs from the cylinder block.
4. Press or draw the liners out through the top of the cylinder block ensuring no damage is done to the parent bores *(cast iron production liners are an interference fit and should be removed with a heavy duty press).*

Preparation for Fitting New Liners

Great care must be taken in handling, transit and storage of new liners.

After removal of the old liners, the parent bore must be thoroughly cleaned both in the top recess of the liner flange and in the parent bore itself.

A check must be made to ensure that the whole areas of contact with the liners in the cylinder block are free from burrs, corrosion or damage. Remove any burrs present.

Ensure that the new liner is thoroughly clean before fitting. If cleaning fluid is used to wash the liner, it is important that the liner parent bore be thoroughly dried and well oiled before fitting.

Throughout the whole operation, extreme cleanliness is essential as the entry of the smallest particle of grit or other foreign matter is sufficient to cause local distortion of the liner bore.

To Fit New Liners

1. Lubricate the outside diameter of the liners with clean oil which should be applied by means of a pressure can. The use of a brush is not recommended.
2. Press or draw in the new liners using a suitable shouldered metal disc ensuring that the flanges at the top of the liners do not foul the counter-bore at the top of the parent bore thus causing distortion at the top of the internal diameter of the liner.

When fully seated, the top face of the liner flange should be between 0.002 inch (0.05 mm) above 0.004 inch (0,10mm)below the top face of the cylinder block. For service liners, the acceptable limit is *3.6015 / 3.6025 inch (91.48 / 91.50 mm).* Each new liner should be checked in three positions – top, center and bottom; the readings being taken transversely and parallel to the center line of the cylinder block at each position.

Having fitted the new liners, the remainder of the re-assembly operations are a reversal of the removal procedure.

To fit New liners (Pre finished liners)

If desired and where the necessary boring equipment is available, unbored cast iron liners (as used in factory production) may be used to replace existing cast iron liners. These are an interference fit in the cylinder block as compared with the transitional fit of pre-finished liners and require boring and honing into a diameter of *3.6015/ 3.6025 inch (91,48 / 91,50 mm)*

For best results the bores should be diamond honed at an inclusive angle of 30° to 35° followed by plateau honing at an inclusive angle of 15° to 35° to a finish of 32/48 micro inches (0.8/1.2 microns) center line average.

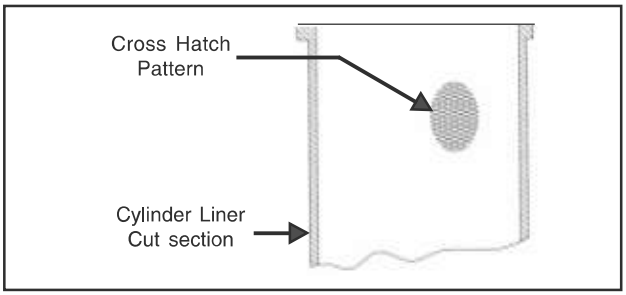


Fig. G 1 Cylinder liner / Hatch pattern

Section H
Crankshaft and Main Bearings

The crankshaft runs in four pre-finished re-placeable shell bearings lined with aluminium tin.

The crankshaft is fitted with two cast iron counter weights, one at the front crank web and one at the rear crank web to give full rotating balance.

The main bearings are located in position by tabs fitting into slots machined in the bearing housings.

The seal at the rear end of the crankshaft is a lip seal fitted in a one-piece housing.

Fitting New Main Bearings and Thrust Washers

Under normal circumstances, by the time the main bearings and thrust washers require renewing, the crankshaft will need to be removed for regrinding. However, if for any reason one or more of the bearings or thrust washers have to be renewed or removed for inspection, this can be carried out without removing the crankshaft from the engine.

1 . To remove a main bearing, take off the cap of the bearing in question. For the rear main bearing cap, see (1) in next column.

2. Do not remove more than one bearing cap at a time.

3. Loosen the remaining bearing cap set screws one or two turns.

4. Remove the lower half of the bearing from the bearing cap.

5. With a suitable piece of wood push out the top half of the bearing by rotating it on the crankshaft, applying the tool to the side opposite the bearing lip. The locating lips are on the camshaft side of the engine.

6. Inspect the bearing shells and if they require renewing, insert a new half bearing in the top, inserting the plain end first. Fit new half bearing to cap.

7. Replace cap and tighten setscrews lightly before proceeding to the next bearing.

8. Having replaced the bearing and caps, pull down the setscrews with a torque wrench set to the tension given on Page 6.

The thrust washers fit in recesses provided on either side of the rear main bearing housing and cap.

1. To renew the thrust washers, remove the rear main bearing cap. Before doing this it will be necessary to release the lip seal and housing.

2. Remove the two bottom half thrust washers from the main bearing cap.

3. The two top half thrust washers can be removed by sliding them round from one side with a piece of wood or similar material and rotating them until they can be removed.

4. To fit new thrust washers, lightly coat the two upper halves with lubricating oil and slide in the recesses provided on either side of the rear main bearing housing. The steel side of the thrust washers should be towards the bearing housing.

5. Renew the main bearing cap “O” rings (lip seal crankshafts only). Lightly coat the grooves machined in the cap butt faces with jointing compound and ensure that the grooves are free of jointing compound.

6. Place the two lower halves of the thrust washers on either side of the rear main bearing cap and replace the cap.

7. The bearing cap securing setscrews should be pulled down with a torque wrench set to the tension given on page 6 Check crankshaft end float.

8. Refit the lip seal and housing.

To Remove Crankshaft

1. Remove sump and lubricating oil pump (Ref. Section L / Page 51).

2. Remove water pump (Ref. Section M / Page 56).

3. Remove crankshaft pulley.

4. Take off timing case front cover and remove idler gear.
5. Remove starter motor, flywheel & flywheel housing. When removing the flywheel, fit two guide studs in the crankshaft flange for support.
6. Remove connecting rod caps and big-end bearings.
7. Remove the bolts securing the lip seal housing and remove.
8. Remove setscrews and remove main bearing caps and half bearings.
9. Lift out crankshaft.

Should it be necessary to replace the crankshaft gear, it should be ascertained that the scribed timing mark is to the front when the gear is fitted. The distance piece between the gear and the crankshaft should be fitted with the chamfer to the inside.

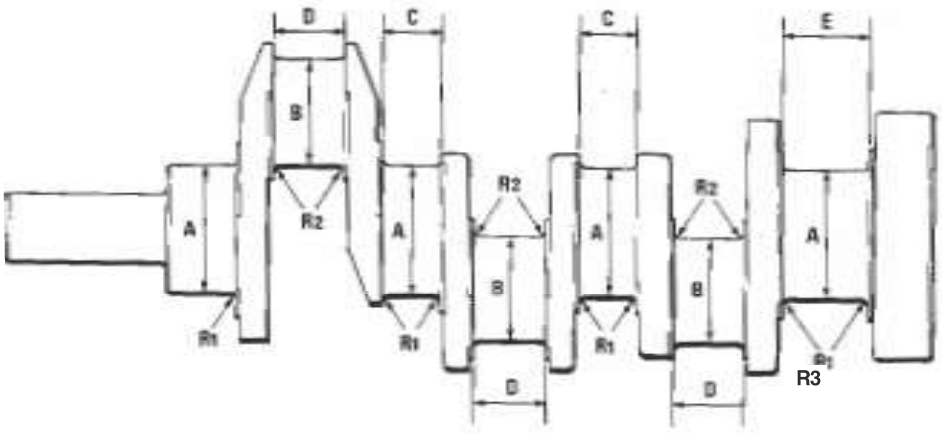
If the main bearings are to be used again they should be suitably marked so that they may be installed in the same position from which they were removed.

Balance Weights

Should it at any time be necessary to replace crankshaft balance weights, these are normally supplied in wired pairs and must be fitted as a pair. Should a single balance weight require replacing, this must be done selectively so that there is no greater weight variation than 1 oz (0.028 Kg.) between individual weights. (Refer Fig. H 6)

Regrinding the Crankshaft

Before proceeding to regrind the crankshaft, the following points should be checked to ensure it is suitable for futher machining.



	0.010 in (0,25 mm) Undersize	0.020 in (0.51 mm) Undersize	0.030 in (0,76 mm) Undersize
A.	2.7385/2.7393 inch (69,56/69,58 mm)	2.7285/2.7293 inch (69,30/69,32 mm)	2.7185/2.7193 inch (69,05/69,07 mm)
B.	2.2384/2.2392 inch (56,86/56,88 mm)	2.2284/2.2292 inch (56,60/56,62 mm)	2.2184/2.2192 inch (56,35/56,37 mm)

C. 1.2277 inch (31,184 mm) maximum
D. 1.575 inch (40,00 mm) maximum
E. For crankshafts with lip type rear seal .- [1.861 inch (47.27 mm) maximum]
R1 0.125/0.140 inch (3,1813, 56mm) all journals Except Rear
R2 0.1875/0.2031 inch (4,76/5,16 mm) all crank pins
R3 0.1562/0.1662 inch (3,97/4,22mm)
Surface finish of crankpins, journals and fillet radii 16 to 8 micro inches (0,4/0,2 microns) C.L.A.

Fig. H1 Crankshaft

(a) The crankshaft should be crack-detected before regrinding. It must, of course, be remembered to demagnetise the crankshaft after crack-detecting, in order to remove any polarisation which may be present.

(b) The main journal and crankpin diameters should be checked to ascertain the next appropriate under size to which the crank- shaft can be-reground, i.e. 0.010 inch (0.25 mm), 0.020 inch (0.51 mm), or 0.030 inch (0.76 mm). Ref. Fig H 1.

If the crankshaft requires to be reground below 0.030 inch (0.76 mm) it is recommended that a new crankshaft is fitted.

During regrinding, all the limits must be adhered to, and the main journals and crankpins must be free from grinding marks.

NOTE: *It is important that the RADII on the main journals and crankpins are maintained. If these are neglected, a fatigue fracture is liable to occur.*

After regrinding, the sharp corners on the oil holes should be removed and the crankshaft crack-detected again and demagnetised.

Replacing Crankshaft

1. Ensure that all oil-ways are clear.
2. Check main bearing setscrews for stretch or damage to threads. Affected setscrews must be scrapped.

In no case should setscrews other than those supplied by the engine manufacturer be used as they are of special heat treated highgrade steel.

3. Clean bearing housing and place top half bearing in position.
4. Place crankshaft in position.
5. Lightly smear the two upper thrust washers with lubricating oil and slide in to the recesses provided on either side of the rear main bearing housing, with the steel side or plain surface of the washers towards the housing.
6. Fit lower halves of main bearings to bearing caps and place in position ensuring that the thrust washers on No. 4 main bearing cap are fitted correctly.
7. Renew the rear main bearing cap “O” rings as shown in Fig. H 7
8. Lightly coat the rear main bearing cap butt faces with jointing compound, only coat outboard of the grooves machined in the cap butt faces and ensure that the grooves are free from jointing compound.
9. When replacing the main bearing caps, ensure that they are fitted in their respective positions, also that they are fitted the correct way round. The caps are numbered, No. 1 commencing at the front of the engine. Each cap is also marked with a serial number and when fitted, this number should read in line with the serial number stamped on the cylinder block bottom face.

For final tightening of the setscrews, a torque wrench should be used, set to the tension given on page 6.

When refitting the crankshaft pulley, ensure that the pulley setscrew is tightened to the correct torque as given on page 6.

Re-assemble engine as required and to the instructions given for the various operations.

Lip Type Crankshaft Rear End Oil Seal

A circular, spring loaded, lip seal is fitted, which locates on the periphery of the flange of the crankshaft. On production, this seal is fitted with its rear face flush with the rear face of the single piece housing.

This type of seal is easily damaged and extreme care should be taken when handling and fitting it to its housing or to the crankshaft. Any visual damage across the lip of a new seal will cause leakage and prevent bedding in of the new seal.

The seal is designed to function correctly with the direction of rotation of the engine and for identification purposes, the seal is marked with an arrow.

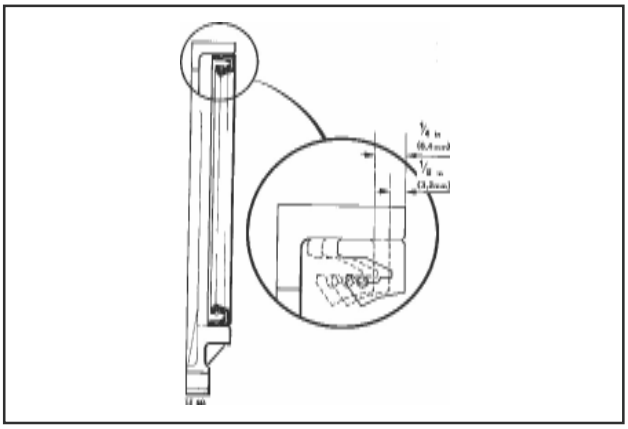


Fig. H.2 Crankshaft Seal – Single Lip (Old Type)

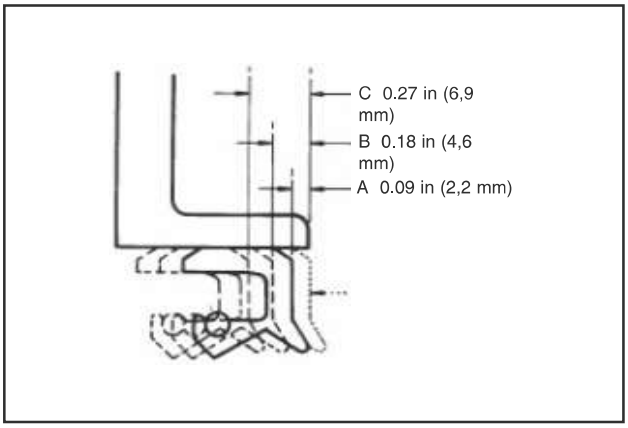


Fig. H.3 Crankshaft Seal – Double Lip (New Type)

Earlier seals have a flat face as shown in Fig. H 2. Later seals have a protruding dust lip from the rear face as shown in Fig. H 3.

To Fit Lip Seal in its Housing

On production, the old type seal was fitted flush with the rear face of the housing (Fig. H 2) but the new type seal is fitted deeper into the housing at 'A' (Fig. H 3)

In service, when a new seal is fitted to a worn crankshaft, it should be pressed further into the housing. In the first instance it can be pressed in to 1/8 inch. (3.2 mm) for old type seals or position 'B' for new type seals or, if this position has been used, to 1/4 inch. (6.4 mm) for old type seals or position 'C' for new seals.

If a new type seal is used in place of an existing old type seal, position'C'should be used if the old seal was fitted 1/8 inch (3.2 mm) below the housing face.

If all three positions have been used, it may be permissible to machine the worn sealing area of the crankshaft flange but not the spigot area on which the flywheel locates (Fig. H 4)

When a new seal is fitted to a new or reconditioned crankshaft in service, it should be fitted in the production position, but if latest seal is not to be used in a wet back end application, it must be fitted flush with the housing rear face 'D' (Fig. H 2)

When pressing in the latest type seal, ensure that the adaptor has a suitable recess to clear the protruding dust lip. Seal guide can be used with both type seals.

Before fitting the seal in the housing, carefully examine the seal for damage, especially on the lip and outside diameter.

Using clean engine lubricating oil, lubricate the outside diameter of the seal and the inside diameter of the housing.

Press the seal into the housing to the required position, taking care that the seal is entered and pressed in squarely, otherwise damage to the outside diameter of the seal may occur, or if it is not square in the housing when fitted to the engine, it may leak.

The seal and housing should be fitted, using suitable seal guide as follows:-

Clean the faces of the cylinder block and oil seal housing, and the outside diameter of the crankshaft flange.

Check that the seal and the outside diameter of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position as previously detailed.

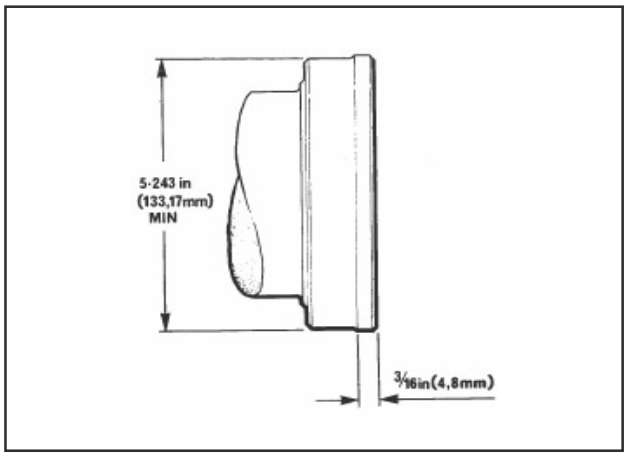


Fig. H.4 Crankshaft Flange Machining dimension

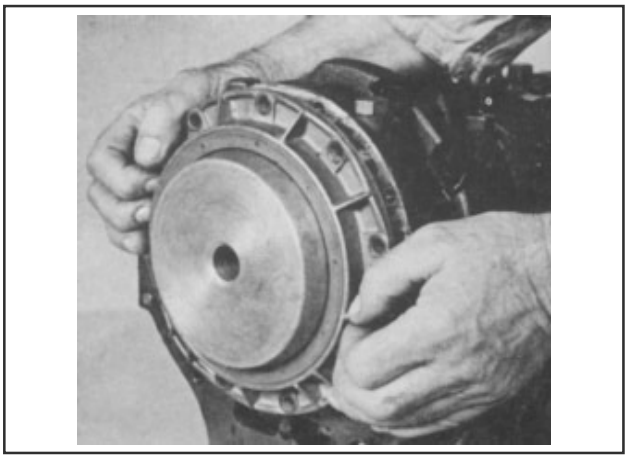


Fig. H.5 Crankshaft Seal Housing Fitting

Ensure that the two dowels are fitted in the cylinder block. Coat both sides of the joint with jointing compound and position the joint over the dowels in the block.

Using clean engine lubricating oil, lubricate the crankshaft flange, the seal and the seal guide.

The lubrication of the seal is necessary to prevent damage that may be caused by initial dry running.

Position the seal and housing on the seal guide, locate the guide on the crankshaft flange and gently press the seal and its housing into position on the flange, locating the housing on its dowels (See Fig. H 5)

Withdraw the guide and secure the housing with setscrews and washers.

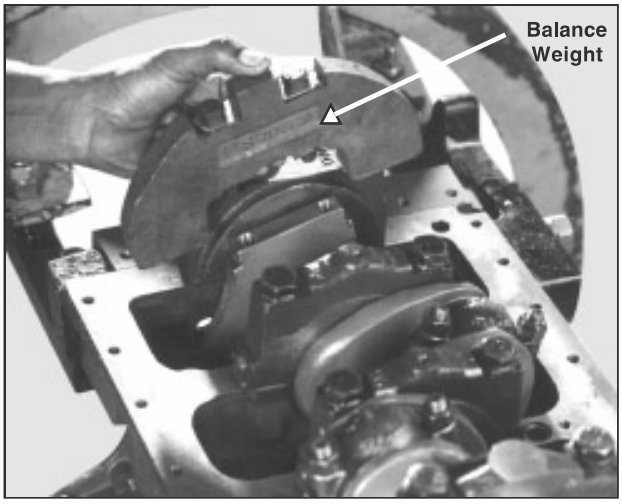


Fig. H. 6 Balance Weight

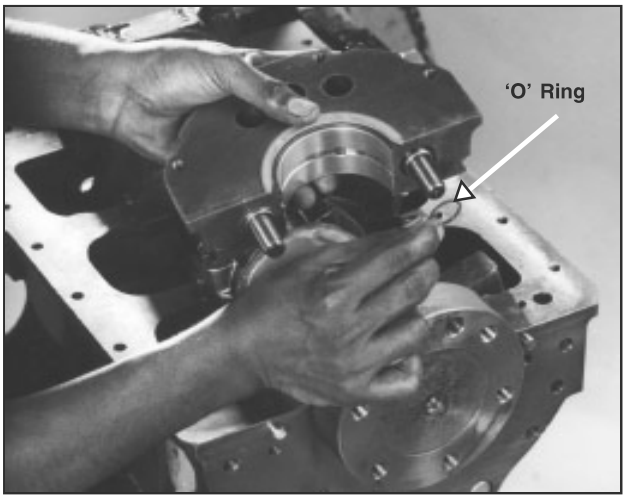


Fig. H. 7 Rear Main Bearing Cap 'O' Ring

Section J
Timing Case and Drive

The camshaft is carried high up on the off side of the cylinder block, the construction of which eliminates push rods.

It is driven from the front of the crankshaft by means of gears.

The timing gears are enclosed by a diecast timing case cover.

To Remove the Timing Case Cover

1. Loosen the dynamo/alternator mounting bolts and remove the fan belt.
2. Loosen off the hose on the hoses fitted to the water pump and remove the water pump.
3. Remove the setscrew crankpulley and washer, the setscrew is of a normal right hand thread into the crankshaft.
4. Remove the crankshaft pulley.
5. Remove the engine breather pipe.
6. Remove the alternator
7. Remove the alternator brackets and adjustable linkage.
8. Remove the timing case cover setscrews Two long bolts pass through the timing case to secure a cover at the rear of the timing case, blanking off the power take off bore. In addition one long bolt (top right) secures the water pump body to the cover and the timing case.
9. Remove the timing case cover taking care not to damage the crankshaft front oil seal which is located in the timing case cover.

To Renew the Crankshaft Front Oil Seal

1. Carefully extract the oil seal from the timing case cover using a suitable press.
2. Locate a new seal in the timing case cover with the lip of the seal towards the inside of the cover.
3. Seals encased with a metal rim should be coated with jointing compound before being pressed into the timing case cover bore.
4. Press the new seal in position using a suitable dolly to ensure the seal is square in the bore of the cover.

To Replace the Timing Case Cover

1. Clean the jointing faces of the timing case and its cover using a new joint, refit the cover and water pump taking care not to damage the front crankshaft oil seal as the cover is placed over the crankshaft front end.
2. For purposes of centralizing the cover around the crankshaft, fit the pulley to the crankshaft and fix the position of the cover to the timing case by two or three setscrews. Remove the pulley and refit all the setscrews to the timing case.
3. Refit the engine breather pipe.
4. Replace the crankshaft pulley, washer and dognut or setscrew.
5. Refit the hoses to the water pump and tighten the clamps.
6. Replace the alternator bracket, alternator and fan belt and tighten the alternator retaining bolts.

Fig. J.1 Cam Gear / Idler Gear backlash

Timing Gears

The camshaft and the fuel pump gears are driven by the crankshaft gear through an idler gear. All the gears are suitably marked during production to facilitate retiming the marks being in line when No. 1 piston is at top dead center on its compression stroke. It will be appreciated that these timing marks will not align at every rotation of the crankshaft where No.1 piston is at T.D.C. compression.

If it is necessary to replace any of the timing gears, ensure that there is a minimum backlash of 0.003 inch (0.08 mm) – Ref. Fig. J1.

The backlash between the crankshaft gear and oil pump idler gear should be 0.0075 in to 0.0125 inch (0.19 to 0.32 mm) – Ref. Fig. J 2.

To Remove the Idler Gear and Hub

1. Turn the crankshaft until all the timing marks on the gears are in mesh with the idler gear.
2. Bend back the locking washer on the idler gear retaining setscrew, and remove the setscrew, locking washer and idler gear retaining plate.
3. Remove the idler gear from its hub.
4. Remove the idler gear hub from its machined location in the timing case. (Ref. Fig. J 3).

To Replace the Idler Gear and Hub

1. Replace the idler gear hub so that the small locating peg is entered into the through drilling in the hub, ensuring the hub is fully located. The flange of the hub should be flush with the timing case.
2. Fit the idler gear on the hub with the long tapered center boss towards the cylinder block and the timing marks aligned.
3. Replace the idler gear retaining plate, locking washer and retaining setscrew. Fully tighten the setscrew with a torque wrench and bend up the locking washer. Ensure that the idler gear has end float on the hub. The end float should be between 0.005 in to 0.015 in (0.13 to 0.38 mm).

To Remove the Camshaft Gear

1. Release and remove the three securing setscrews and washers.
2. The camshaft gear may now be removed from the camshaft

To Replace Camshaft Gear

1. Remove idler gear and release the rocker assembly to facilitate turning of camshaft. On the spigot of the camshaft will be seen the letter “D” stamped adjacent to a fixing hole and on the camshaft gear another letter “D” will also be seen stamped adjacent to a fixing hole. Install the camshaft gear to the camshaft, ensure the holes with the latter “D” stamped adjacent to them are in line.
2. Replace and secure the three washers and setscrews.
3. Turn the camshaft until Nos. 4 and 6 cams are upright, this can be checked by watching the tappets, and this is the approximate position for aligning timing marks.
4. Fit idler gear, aligning all timing marks and secure the rocker assembly.

To Remove the Fuel Pump Gear

1. Remove the idler gear.
2. Release and remove fuel pump gear securing setscrews.
3. Remove fuel pump gear, taking care not to damage the dowel.

Fig. J.2 Checking Oil pump idler gear backlash

To Remove the Fuel Injection Pump

The fuel injection pump is secured to the back of the timing case on the left-hand side of the engine and the fuel pump driving gear is securely attached to the shaft of the pump by three setscrews. The location of the gear to the pump shaft is determined by a dowel.

On the timing case front cover is a small inspection cover and removal of this cover gives access to the setscrews securing the driving gear to the pump.

1. Turn the engine to T.D.C. No. 1 cylinder on compression.
2. Remove the fuel pipes to the pump and blank off all ports against the ingress of dirt.
3. Remove the throttle and stop controls from the governor housing of the pump.
4. Remove the cover from the timing case front cover.
5. Carefully remove the three setscrews and washers securing the gear to the fuel pump, great care must be exercised in removing these setscrews for should one be dropped into the timing case, considerable time and labour would be involved in recovering it.
6. Release and remove the three nuts,flat and spring washers securing the flange of the fuel injection pump to the back of the timing case.
7. Remove the fuel injection pump.

To Replace the Fuel Injection Pump

1. Check that the slot in the fuel pump shaft is in approximate position to the dowel in the gear and install the pump to the three studs on the back of the timing case and retain with the three falt and spring washers and nuts, but do not tighten the nuts.
2. After ensuring that the dowel in the fuel pump driving gears is located to the slot in the fuel pump shaft, secure the gear to the pump by the three setscrews and spring washer taking care not to bind the gear on the pump shaft.
3. Tighten the three securing nuts.
4. Replace the inspection cover to the timing case front cover.
5. Replace the throttle and stop control.
6. Refit all the fuel pipes to the pump.

To Replace the Fuel Pump Gear

1. If necessary fit dowel into fuel pump gear.
2. Replace gear, locating dowel between gear and fuel pump.
3. Replace and secure washers and setscrews.
4. Refit idler gear, aligning all timing marks.

NOTE : *Please refer Appendix I for more detail.*

To Remove the Camshaft

1. Remove the rocker shaft assembly as previously described.
2. Remove the timing case cover as previously detailed.
3. Turn the crankshaft until all the timing marks are aligned.
4. Lift the tappets and remove the camshaft and gear from its location in the cylinder block taking care not to damage the journals, cams or tappets.

To Replace the Camshaft

1. Lift the tappets, and carefully fit the camshaft and gear continually turning the camshaft. Take care not to damage the journals, cams or tappets. Make sure the timing marks on the idler gear and camshaft are aligned correctly.
2. Replace timing case cover.
3. Refit the rocker shaft and reset the tappets.
4. Replace cylinder head cover.

Camshaft Thrust

The camshaft end float is taken up by a steel spring rivetted to the timing case front cover.

To Remove the Timing Case

1. Remove the timing case cover as previously detailed.
2. Release and remove the rocker shaft assembly.
3. Remove the sump as explained under “Lubricating System” (Section L).
4. Remove timing case bottom cover.
5. Unscrew the retaining setscrew and remove the locking washer, idler gear and spigot.
6. Lift the tappets and remove the camshaft, complete with its gear, taking care not to damage the cams or bearing journals.
7. Release the three setscrews and remove the driving gear from the fuel pump.
8. Remove all cables and pipes from the fuel injection pump. When removing the high pressure pipes from the pump, release the pipes at the atomiser end and remove the pipes.
9. Unscrew and release the three nuts, spring washers and flat washers securing the fuel pump flange to the timing case and remove the fuel injection pump. Ensure that all inlet and outlet connections of the fuel injection system are effectively sealed against the ingress of dust and dirt by the use of suitable caps and plugs.
10. Remove the setscrews and spring washers securing the timing case to the block and with a light tap remove the timing case from the cylinder block.

To Replace the Timing Case

1 . For the purpose of correct location of the timing case, it is advisable to fit and fully locate the idler gear hub to the cylinder block.
2. Fit a new gasket to the cylinder block front face and replace the timing case.

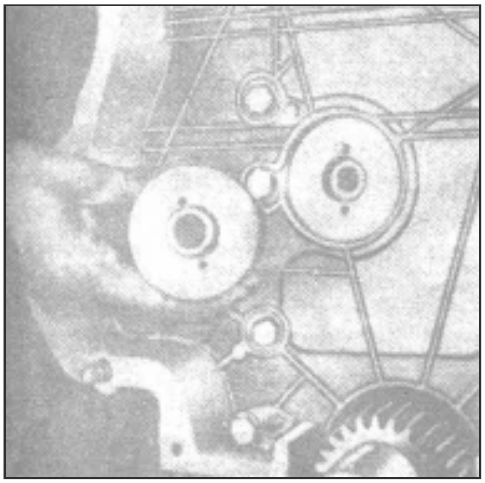


Fig. J. 3 Idler Gear Hub Location

3. Replace timing case bottom cover ensuring it is correctly aligned with the front face of the timing case.
4. Secure the fuel injection pump to the back of the timing case matching the scribed marks.
5. Turn the engine crankshaft until No. 1 piston is at top dead center (key on the front of the crankshaft vertifcally upwards)
6. Fit the fuel pump gear to the fuel pump, locating the dowel between the gear and pump.
7. Lift the tappets and replace the camshaft and its gear, turning the camshaft as it is being entered into the camshaft tunnel.
8. Replace the idler gear on its spigot, with the long tapered flange of the gear towards the cylinder block and the timing marks on the crankshaft gear, fuel pump gear, camshaft gear and idler in line.
9. Replace the sump as described in the “Lubricating System”.
10. Replace the timing case cover.
11. Refit all fuel pipes and controls.

Section K
Timing

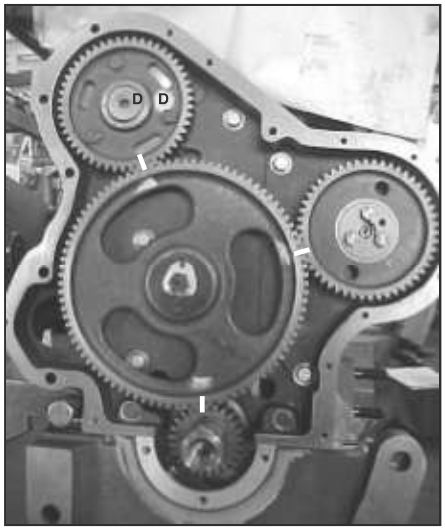


Fig. K.1 Timing Gears

The timing or the resetting of the timing can be simply and quickly carried out if the following instructions are kept in mind.

It is well to remember that the removal of the cylinder head does not in any way affect the timing of the engine.

Timing Marks

When the engine is timed at the factory, certain marks are stamped on the gears, so that if for any reason the timing must be distrubed, then the engine can easily be reset to it's original timing.

The method of marking is as follows:- With the engine timing correctly set, the engine is turned until No. 1 piston is at T.D.C. on its compression stroke. In this position, scribed lines or center punch marks are marked on the idler gear to correspond with lines or center punch marks on the camshaft, fuel pump and crankshaft gears respectively (Ref. Fig. KI).

NOTE: *With all the timing marks aligned, the crankshaft will have to be turned 18 times before all the timing marks will align again.*

Fuel Injection Pump Timing Marks

On the fuel pump mounting flange is a scribed line which, when the fuel pump is fitted should coincide with a scribed line on the rear face of the timing case. Providing these scribed lines are in alignment and the fuel pump gear correctly fitted, then the fuel pump timing should be correct.

To Reset Engine Timing

Remove atomisers.

Bring No. 1 piston to T.D.C., No. 1 piston being on its compression stroke. The T.D.C. that has been obtained can be checked by examining the flywheel where the T.D.C. **mark should be central within the inspection opening, or the front of the crankshaft where the key for the fan belt pulley should be at the top of its periphery.**

Fit the camshaft gear ensuring the letter "D" stamped adjacent to one of the fixing holes is in alignment with the letter "D" stamped on the camshaft hub.

Fit the fuel pump gear. This is dowelled and will only go in one position.

Check that the fuel pump is correctly fitted to the engine with the scribed line on the mounting flange in line with the scribed line on the rear face of the timing case.

With the crankshaft gear fitted, **replace the Idler gear** ensuring the timing marks coincide (Ref. Fig. K.1).

After testing the engine, final adjustments may be necessary to find the perfect injection point. Adjustment may be made by releasing the fuel pump securing setscrews and turning the pump in the direction required.

To Check Valve Timing

Turn the engine until maximum lift is obtained on No. 3 cylinder exhaust valve.

In this position, set the clearance between rocker lever and No. 1 inlet valve to 0.031 inch (0.787 mm).

Now turn the engine in the normal direction of rotation until the tappet of No. 1 inlet valve just tightens.

At this point, No. 1 piston should be at T.D.C. This can be checked by examining the T.D.C. mark on the engine flywheel. The tolerance for valve timing is plus or minus $2^{1}/_{2}°$.

It should be noted that **no adjustment is provided for valve timing.** Provided the gear is correctly fitted to the camshaft (see previous remarks) then the timing can only be one or more teeth off.

When the timing is found to be correct, adjust the valve clearance to 0.012 inch (0.30 mm) cold.

Section L
Lubricating System

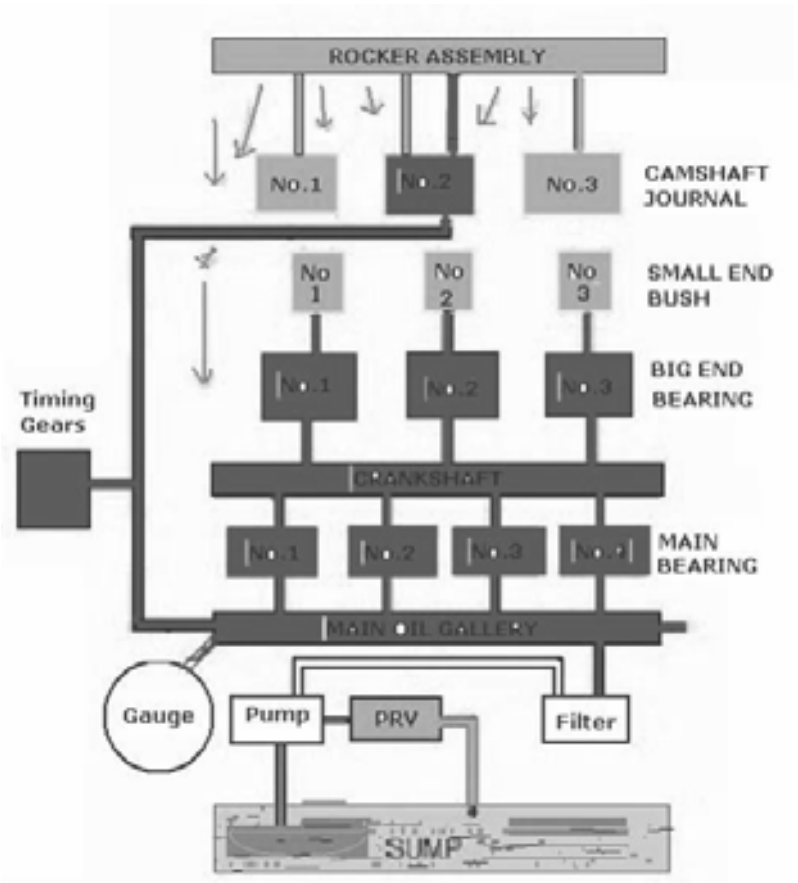


Fig. L1 Engine Lubrication

NOTE : *Lubricating oil Data in Section Q.*

The importance of correct and clean lubrication cannot be stressed too highly and all references to engine oil should be taken to mean lubricating oil which falls within the specifications given in section Q. Care should be taken that the oil chosen is that specified for the climatic conditions under which the engine is operated.

The sump should be filled with a suitable lubricant to the correct level but do not attempt to overfill above the full mark. Before filling or checking the dipstick, ensure the application is on level ground.

Oil Circulation

The system of lubrication (Fig. L.1/ L.2) comprises pressure feed to main and big end bearings, camshaft bearings, rocker shaft and timing gear train.

The pump draws oil through the strainer (where fitted) from the sump and delivers it by a pipe inside the crank case through a drilling in the side of the cylinder block to the lubricating oil filter.

Oil passes through the filter and then through an internal drilling in the cylinder block to the pressure rail which is an internal passage within the crankcase.

Holes drilled in the crankcase webs feed oil from the pressure rail to the main bearings and holes in the crankshaft webs carry oil to the big end bearings. Surplus oil returns to the sump.

An oil seal prevents oil leaking along the crankshaft at the rear end and oil thrown from this seal returns to the sump.

The small end bushes are lubricated by splash and lubricating oil mist.

Running across the front of the cylinder block is an internal passage which connects with the pressure rail. The oil comes out from this passage on the camshaft side of the engine and is delivered along an external pipe to the lower drilling in the center camshaft bearing journal.

As the camshaft revolves, oil is picked up and carried round in the narrow slot machined on the center camshaft journal until it escapes through the upper drilling in the camshaft tunnel. The oil then flows through a pipe to the cylinder head whence another pipe conveys it to the hollow rocker shaft which feeds oil to the rocker lever bushes, etc.

It will be appreciated that due to the small capacity of the slot on the camshaft journal, only a reduced quantity of oil can pass to the rocker shaft during each revolution of the camshaft.

The overflow of oil from the rocker shaft flows from the cylinder head into the camshaft tunnel and from the front of the tunnel onto the timing gears and then returns to the sump.

Further lubrication for the timing gears is provided by means of a drilling in the block between the horizontal drilling referred previously and the idler gear spigot. Oil from this drilling escapes through a hole in the idler gear boss.

Oil Pressure

See that oil pressure is registered on the gauge.

The actual pressure may vary with individual engines but the oil pressure at maximum engine speed and normal working temperature should be 30-60 psi (2 - 4 bar).

There will be a pressure drop while idling and a slight decrease in normal working pressure when the engine is hot.

If the oil pressure as registered on the gauge is below normal, check the following in the order given below:

1. Dipstick. Ensure the sump oil level is up to the “full” mark.
2. Oil pressure gauge. Check for accuracy with master gauge.
3. Lubricating oil filter. May be choked. Renew element.
4. Sump strainer may be plugged. Remove, clean and replace.
5. Lubricating oil pump. Ensure that suction and delivery pipe unions are tight.
6. Oil pressure relief valve. Foreign matter may be preventing valve from closing.

Lubricating Oil Filters

The importance of using clean lubricating oil in the first place, and providing means to ensure that it is always clean in use, is hardly second to the importance of cleanliness in respect of the fuel.

It is imperative, therefore, that lubricating oil filters are not neglected.

To ensure cleanliness, filters are incorporated.

1. Oil Filler strainer.
2. Sump Strainer.
3. Main (full flow) filter.

The purpose of the oil fill strainer is to prevent large objects entering the sump when the engine is being filled with lubricating oil.

The sump strainer consists of a perforated container which is fitted over the suction pipe of the oil pump.

This strainer requires no special attention, but it should be cleaned anytime the sump is removed.

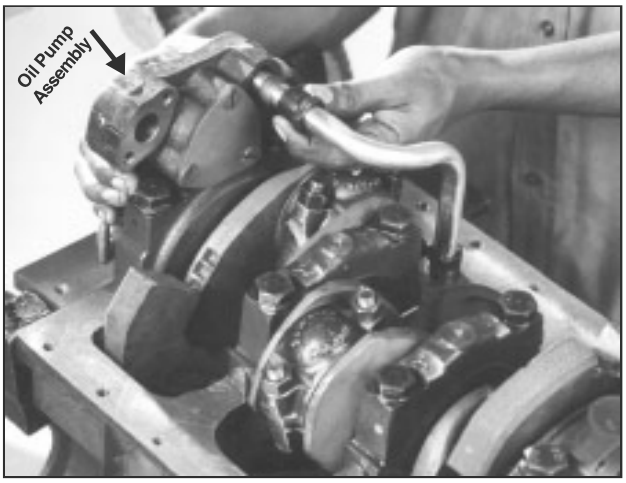


Fig. L.2 Oil Pump – Removal / Refitting

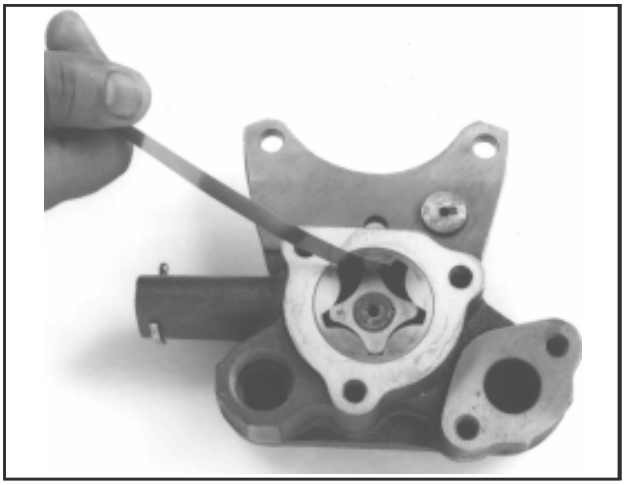


Fig. L.3 Checking Oil pump clearance (Inner rotor to Out rotor body)

Main (Full Flow) Filter

This filter incorporates either a separate paper element fitting in a filter bowl or a screw on canister where the element is integral with the canister. Both elements should be renewed not cleaned, at the appropriate time, as given in Section C.

To Renew the Canister:-

1. Unscrew and discard old oil canister.
2. Clean the filter head and the threaded adaptor.
3. Using clean engine lubricating oil, liberally oil the top seal of the replacement canister.
4. Fill the new canister with clean lubricating oil, allowing time for the oil to filter, through the element. Screw the replacement canister on to the filter head until the seal just touches the head and then tighten by hand as detailed in the instructions on the canister. Where a tool is available, tighten to 15 lbf. ft. (20 Nm.).
5. Run the engine and check for leaks. Check the oil level after running and top up as necessary.

Paper Element Replacement (Early Type) :-

1. Unscrew the center bolt at end of cover.
2. Drop filter bowl clear.
3. Remove element and discard.
4. Before replacing new element, clean inside of filter bowl with cleaning fluid.
5. Ensure that the rubber joints are in good condition, if not, replace by new.
6. Start engine and check for leaks. Check oil level after running and top up as necessary.

The bolt securing the filter bowl should be checked for tightness after the first 25 hours of running.

Oil Pressure Relief Valve

The oil relief valve which is located in the oil pump body prevents the pressure becoming excessive as might otherwise happen when the oil is cold.

The relief valve comprises a spring loaded plunger.

When the predetermined pressure setting is exceeded, the valve opens and some of the oil is released, to return to the sump. That continues until the oil warms up and flows at the desired pressure. The valve then closes.

When to replace the Oil

The oil in the sump must be drained in accordance with preventive maintenance, Section C, and replaced by clean new oil of a specification suitable for the climate (Section Q)

To Remove Sump

Remove drain plug and drain off oil.

Remove dipstick.

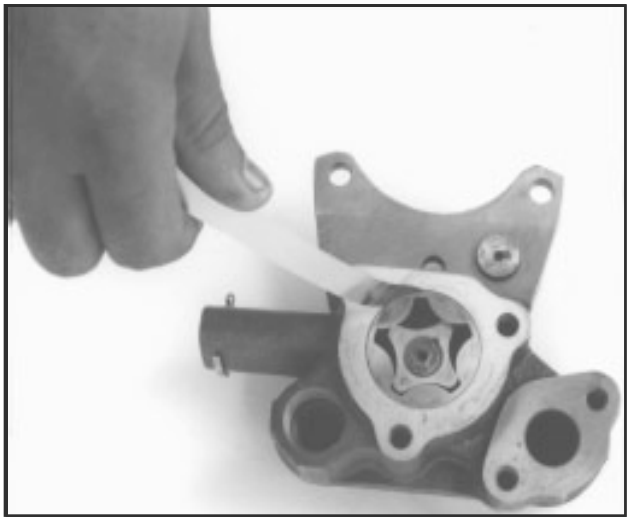


Fig. L.4 Checking Oil pump clearance (Outer rotor to body)

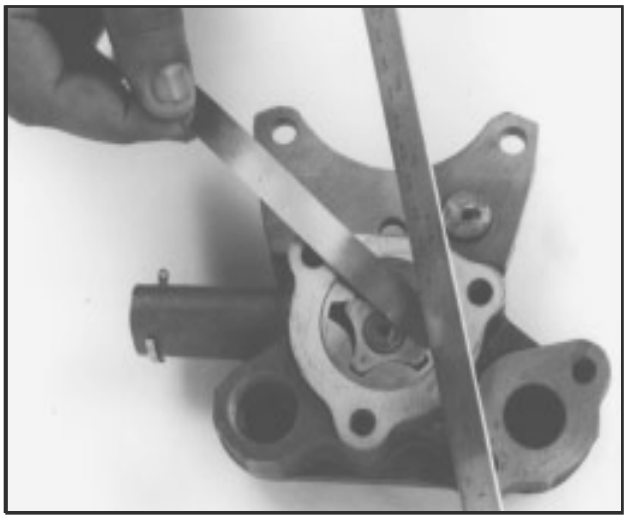


Fig. L.5 Checking Oil pump clearance (Top of rotors to body)

Where necessary, remove setscrews securing rear of sump to flywheel housing.

Remove all setscrews securing sump to crankcase and lower sump.

To Replace sump

Remove all traces of old joints and cork strips from timing case bottom cover and rear main bearing cap.

Lightly smear crankcase faces with a thin coating of jointing compound and place seals in position ensuring all holes lined up.

When placing seals in position, it is important that the mitred ends go right up into the recesses of the timing case bottom cover and rear main bearing cap.

Lightly coat cork joints with jointing compound and place in the grooves provided in the timing case bottom cover and rear main bearing cap.

Place sump in position and screw setscrews lightly home.

Where applicable, replace setscrews securing rear of sump to flywheel housing.

Tighten setscrews securing sump to crankcase.

Replace dipstick and sump drain plug.

Pour oil in the sump and ensure oil level is up to the “full” mark on dipstick.

To Remove Oil Pump

Remove sump (see previous heading). Remove the three setscrews at the bottom of the timing case front cover and the two nuts at the bottom of the timing case when the timing case bottom half can be removed.

Disconnect the delivery pipe from the oil pump to cylinder block.

Remove circlip and move oil pump idler gear forward.

Unscrew the three setscrews securing the oil pump to the front main bearing cap and remove oil pump. (Fig. L2)

To dismantle Oil Pump

Remove suction and delivery pipes.

Remove oil pump idler gear.

Using a special screw driver, unscrew the three screws and remove the pump end plate.

The outer rotor can then be removed.

The oil relief valve is located in the body of the lubricating oil pump. It is an adjustable valve but unless special test equipment is available, no attempt should be made to dismantle it. The relief pressure is set and adjusted before the engine leaves the factory.

Inspection

The clearances for new pumps are given in Section B.

1. Thoroughly clean all parts and inspect the rotors for cracks or scores.
2. Install the driven rotor in the pump body making sure the chamfered edge of the outer rotor enters the pump body first. Check the clearance between the maximum diameter of the inner rotor and the minimum diameter of the outer rotor at all points (Fig. L3).
3. Check the clearance between the outer rotor and the pump body. (Fig. L4)
4. Check the clearance between the top of the rotors and the end of the pump body with feeler gauges and straight edge. (Fig. L 5).

NOTE: *Should an oil pump be worn to such an extent it adversely affects the working oil pressure then a replacement pump should be obtained. The component parts of the oil pump are not supplied individually therefore if any parts require replacing a replacement assembly should be fitted.*

To Re-assemble the Oil pump

Replace outer rotor, inner rotor and shaft in oil pump body.

Replace end cover and secure with three screws.

Press on driven gear and ensure pump rotates freely.

Replace idler gear and circlip

Prime lub oil pump with oil before fitting.

To Refit Oil Pump

Fit oil Pump to front main bearing cap and secure with three setscrews.

Secure idler gear with circlip.

Replace suction and delivery pipes to and from oil pump.

Replace timing case bottom half and secure with two nuts and washers to timing case top half.

Replace the two setscrews and nut at the bottom of the timing case front cover.

Replace sump in accordance with previous instructions.

Before starting, the engine should be turned over while operating the stop control, until oil pressure is registered.

Section M
Cooling Systems

The cooling coolant is circulated by a centrifugal type pump which is mounted on the front of the timing case cover. It is driven by a V-belt from the engine crankshaft and provision is made for fitting a fan on the front end of the water pump pulley.

The pump does not require greasing as the bearings are treated with a special quality grease before assembly.

Fan Belt Adjustment

Belt tension should be adjusted so that, without undue pressure, the belt can be depressed approximately 3/8 in. (10 mm) with the thumb applying pressure at a point midway between the water pump and alternator pulley (Refer Fig. M5)

Adjustment of the belt tension is achieved by altering the position of the alternator. Release the alternator adjusting link and support bracket bolts. Move the alternator to give the correct tension and then tighten the bolts and re-check the tension.

When a new belt has been fitted it is advisable to check the belt tension after a few hours running to ensure that no initial stretching has occurred.

To Remove Water Pump

Remove Fan.

Loosen alternator securing setscrews and remove fan belt.

Remove water pump inlet and outlet hose connections.

Unscrew setscrews securing the water pump and remove.

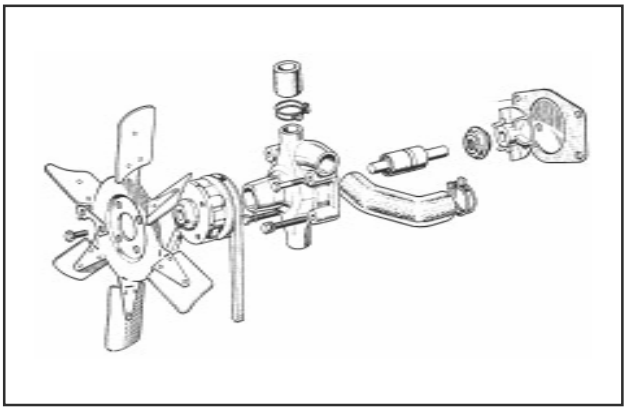


Fig. M 1 – Water pump exploded view

To Dismantle Water Pump

Remove the water pump pulley using a suitable tool. The tapped holes in the pulley can be utilised for this purpose (Ref. Fig. M2).

Press the water pump shaft complete with bearings and impeller from out of the rear of the pump body. Press the shaft and bearing assembly out of the impelier.

Remove the unitised seal from the shaft.

The shaft and bearings are manufactured as one component and cannot be dismantled.

To Re-assemble Water Pump

With the shorter end foremost, press the shaft and bearing assembly into the rear of the water pump body until the bearing housing end is flush with the front of the water pump body.

Fit the unitised seal.

Supporting the shaft at the front end, press the impeller with blades inwards onto the rear of the shaft until a dimension of 0.010 inch (0. 25 mm) to 0.020 inch (0. 51 mm) is obtained between the blades of the impeller and the pump body (Ref. Fig. M3)

Spin the assembly to ensure freedom of rotation.

Replace the four setscrews (used for securing the water pump onto the timing case cover) before pressing pulley on shaft.

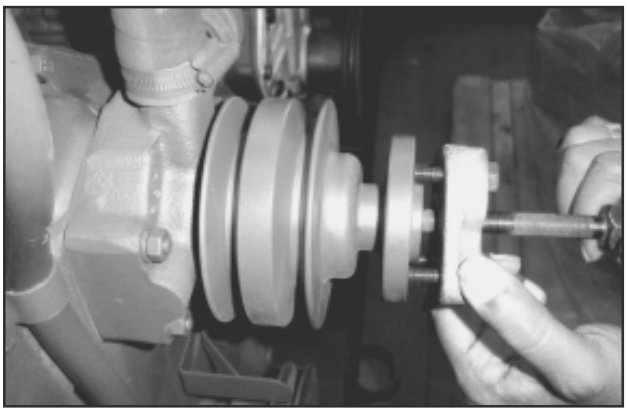


Fig. M 2 – Water pump pulley removal (Twin groove)

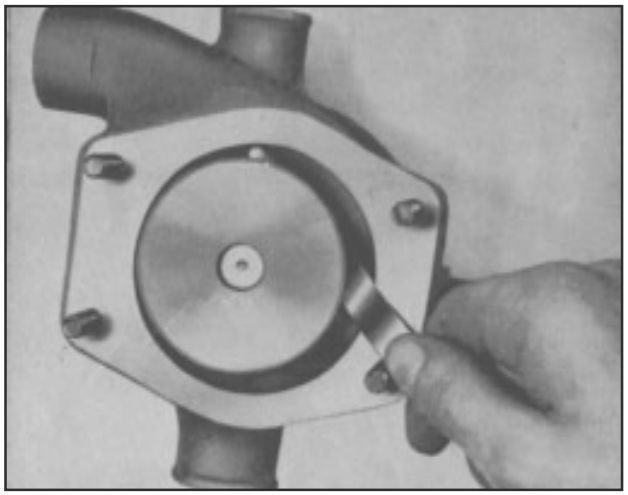


Fig. M 3 – Checking impeller clearance

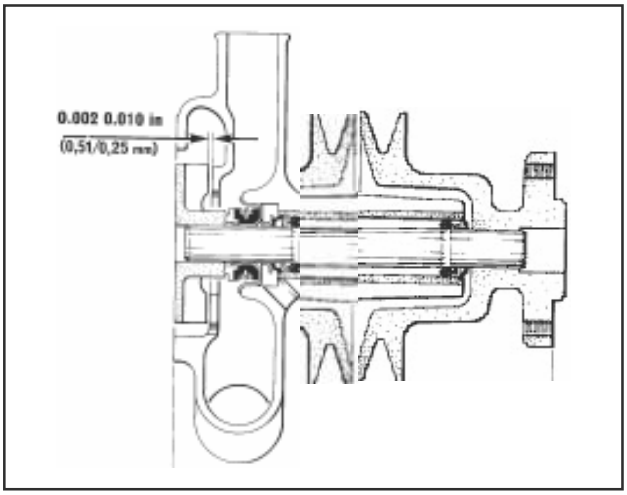


Fig. M 4 – Water pump cut section

Supporting the shaft at the impeller end, press on the water pump pulley until the front end of the fan mounting face is 5.531 in (140.49 mm) from the rear face of the pump body (Ref. Fig. M4).

Recheck the clearance between the impeller blades and pump body, and spin the assembly to ensure freedom of movement.

To Re-fit Water Pump to Engine

Fit new water pump joint, using jointing compound.

Connect up water pump inlet and outlet hose connections.

Replace fan belt and tension.

Replace fan.

Thermostat

A thermostat is fitted in the cylinder head coolant outlet to assist in providing a shorter warming up period for the engine. The thermostat can be removed after the coolant outlet connection and joint have been removed. When refitting the thermostat, ensure that the jiggle pin (if provided) in the top of the thermostat is free to move in its location.

To check the thermostat, suspend it in coolant and heat gradually. With a thermometer, check that the thermostat operates at the temperatures given in Section B. If it is faulty, it should be replaced - no attempt should be made to adjust a faulty thermostat.

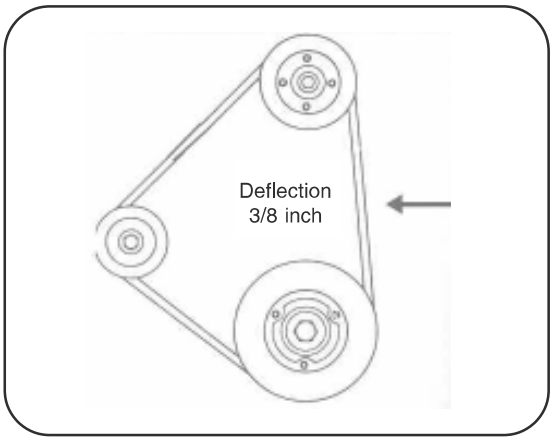


Fig. M 5 – Checking Belt Tension

Section N
Fuel System and Air Cleaners

The principal components of the equipment for delivering the fuel oil to the engine are as follows:

Filters

Fuel Lift Pump (when fitted).

Fuel Injection Pump

Atomisers

So accurate is the manufacture of the fuel injection equipment that the importance of cleanliness when handling fuel cannot be over stressed.

Adequate filters are provided in the system, but much can be done by the operator to ensure that the equipment is maintained in first class condition.

All fuel used must conform to :-

BRITISH STANDARD No. BS. 2869: 1970 CLASS A or I.S: 1460/2000 Grade special or Grade A and must be clean, free from coolant, suspended dirt and other foreign matter. Filtering of fuel before it enters the tank will help, and regular filter changing will ensure that only perfectly clean fuel reaches the fuel injection pump.

Given these conditions, ninety per cent, at least of potential engine troubles would be eliminated. Attention is on that account earnestly directed towards the section of this manual which refers to the care and upkeep of filtering apparatus.

In a pressure fed system, the lift pump lifts the fuel from the tank via the pre-filter (fitted) and then passes it through the dual filter to the fuel injection pump, which delivers it in measured quantities and at appropriate intervals, to the atomisers (Ref. Fig. N1)

Where no lift pump is fitted, i.e. in a gravity fed fuel system, fuel flows from the tank, through a pre-filter, to the dual filter. From there, filtered fuel enters the injection pump which delivers it to the atomisers.

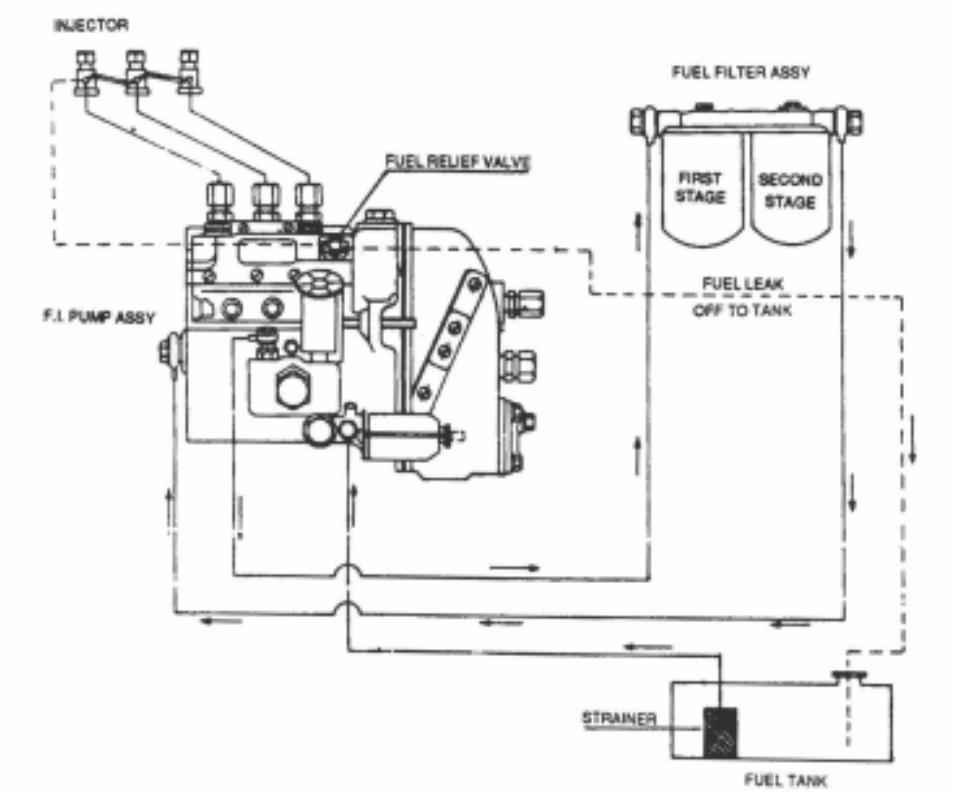


Fig N1 Fuel Pipe Layout (Pressure Feed System)

Fuel Lift Pump (Pressure Feed System Only)

The lift pump is of the plunger type and is driven by a cam on the camshaft of the fuel injection pump, on the side of which it is fitted.

A hand primer is fitted for use if the supply of fuel from the tank has at any time failed, and for bleeding.

The fuel pump is an instrument of precision. Its working parts are made to extremely fine limits and mishandling in any shape or form, or the entry of the smallest particle of dirt into its working parts may damage it and diminish its accuracy of operation. Hence the importance of ensuring that the fuel is thoroughly filtered before it reaches the pump.

When requesting information regarding the fuel pump, the type and number should be quoted. This can be obtained from a plate fitted to the pump gallery above the inspection plate.

Fuel Pipes

No two pressure pipes from the fuel pump to the atomisers are alike. Keep this in mind when replacing.

Examine the nipples which will be found on each end of these pipes.

If the union nuts at any time have been over-tightened, the nipples may have been damaged. If so, leakage will result and the complete fuel pipe will have to be replaced.

In this connection, bear in mind that the working pressure which these joints must sustain is several thousand pounds per square inch. Only a perfect joint is satisfactory.

Assemble the pipe to the fuel pump and atomiser unions to check that the pipe fits square at both ends. Do not fit one end and then bend the pipe to square it with the other union.

When fitting the pipe, tighten the unions alternately a little at a time, first one end and then the other.

If the pipe is square to the unions at each end as described above, no force will be needed to make a good joint. No force should be used.

Use only a standard open ended spanner.

If the union is tightened excessively, the nipple may be damaged. The same danger exists if the pipe is not square to and central with the union.

When changing an atomiser, always remove the pipe entirely. Never undo only one end leaving the other tight. Never bend the pipe.

Atomisers

Each atomiser consists of a steel body, held to the cylinder head by means of a flange and two studs.

The joint between the atomiser and cylinder head is made by a special copper washer between the lower face of the nozzle cap nut and the recess in the cylinder head.

When preparing to fit the atomiser in its place in the cylinder head, care should be taken that only special type of copper washer is used to make this joint. The recess in the cylinder head, the faces of the copper washer and the corresponding face on the nozzle holder cap nut should be perfectly clean if a leakproof joint is to result.

It is advisable to fit a new joint washer when the atomiser is replaced, after having been removed for any reason.

Ensure that the old washer has been removed from the cylinder head or atomiser.

This joint washer should be an easy, but not loose fit for the atomiser nozzle and it is because this is such an important feature that only washers specially made for this purpose should be used and none other. On no account should ordinary spark plug type washers be used.

The atomiser can now be fitted in place, care being taken to see that it is an easy fit in the cylinder head and on the hold down studs, so that it can be placed down on the copper joint without force of any kind. The nuts on the flange should then be tightened down evenly in order to prevent the atomiser nozzle from binding and being damaged in the cylinder head. This is very important since any unevenness in tightening down may cause distortion of the atomiser nozzle resulting in its failure and will most certainly result in blowby.

NOTE : *In S325.3 engine, only one stud with nut and bracket is being used to retain the atomiser (P-Type) in position on cylinder head.*

Maintenance

Atomisers should be taken out for examination at regular intervals. How long this interval should be is difficult to advise, because of the different conditions underwhich engines operate.

When combustion conditions in the engine are good and the fuel tank and filtering system are maintained in first class order, it is often sufficient if the atomisers are tested at lengthy intervals. For details refer to Maintenance Section C.

It is no use taking atomisers out for attention unless an atomiser testing pump is available or spare atomisers are at hand for substitution.

The nearer the ideals of good fitting with adequate cooling and absolutely clean fuel are realised, the less attention the atomisers will need and so the longer their efficient life. In this connection, since there is no other item upon which the performance of the engine depends so much, it pays the user handsomely to see that the engine never runs with any of its atomisers out of order.

Troubles in Service

The first symptoms of atomiser trouble usually fall under one or more of the following headings:

1. Misfiring.
2. Knocking in one (or more) cylinders.
3. Engine overheating.
4. Loss of power.
5. Smoky exhaust (black).
6. Increased fuel consumption.

Often the particular atomiser or atomisers causing trouble may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a approximate 1200 RPM. This will prevent fuel being pumped through the nozzle to the engine cylinder, thereby altering the engine revolutions. If after loosening a pipe union nut, the engine revolutions remain constant, this denotes a faulty atomiser.

After stopping the engine the nuts from the flange of the doubtful atomiser should be removed and the complete unit withdrawn from the cylinder head and test using a atomiser/nozzle tester and/or have tested by a authorized fuel pump station.

Atomiser Pressures

No attempt should be made to service or reset, the pressure of an atomiser unless the proper equipment is available.

When renewing atomisers, reference should be made to the appropriate Parts list to ensure fitment of the correct type.

Air Cleaners

The time period for cleaning the air cleaner depends on operating conditions. Therefore under extremely dusty conditions, the time limit recommended for cleaning should be decreased.

The correct maintenance of the cleaner will greatly assist in extending the life of the engine.

Dry type air cleaner / Maintenance

The dry type air cleaner is provided with paper elements. The elements are not to be removed or cleaned or tapped but should be replaced whenever the element is found plugged which would be identified by restriction indicator or by loss of power or speed drop or emission of black smoke from the exhaust.

A dust collecting bowl is provided at one end of air cleaner. The dust collected in the bowl must be emptied at the end of each day's operation initially. Depending upon the field conditions and the amount of dust collected, the frequency of emptying the above bowl can be altered. The element is to be replaced every 250 hrs.

It should be ensured that the hose connections, metal pipe connections and their clips between the air cleaner outlet and the inlet of air inlet manifold of the engine are secured and are airtight.

Care should be taken to see that no unfiltered air enters the system through these connections.

Section O Fuel injection pump calibration chart

Fuel injection pump calibration chart :

REFERENCE NO : STS-TS-PER 2.5 n1

Edition	:	11.2006
Replaces(edition)	:	05.2004
Test oil	:	F 002 S3E 001
Revision	:	2
Combination No.	:	F 002 A0Z 451-E 040 173 3 000
Injection pump	:	PES 3 A 80 D 320 RS 2000
Governor	:	RSV 375...1000 A4 C 1410 R
Customer	:	Simpson & Co. Ltd.
Engine model	:	S325.3 US Tier-II
Engine code	:	65200
Application	:	Tractor

TEST BENCH REQUIREMENTS

Test oil inlet temperature	:	38°-42°C
Overflow valve	:	F002A10627
Inlet pressure in bar	:	1.5
Test injector	:	0681343009
Opening pressure in bar	:	172.0-175.0
High pressure pipe (ODXIDxlength) in mm	:	6X2X600

(A) CALIBRATION OF PUMP WITHOUT GOVERNOR ACTION

Direction of rotation	:	Clockwise
Prestroke in mm	:	1.95-2.05 (1.9–2.1)
Control rack position in mm	:	18.0–21.0
Cam sequence	:	1-2-3
Cam displacement	:	0-120–240° ±0.5°
Tappet clearance in mm	:	min 0.2

Injection Timing locking : -

BASIC SETTING

Speed-min -1 (rpm)	:	1000
Control rack travel in mm	:	12.95–13.05
Delivery quantity(x)	:	5.75–6.05 in cm³/ 100 strokes
Maximum spread in cm³	:	0.3 (0.4)
Speed-min -1 (rpm)	:	375
Control rack travel in mm	:	4.9-5.1
Delivery quantity(x)	:	0.65–0.95 (0.45–1.15) in cm/100 strokes
Maximum spread in cm³	:	0.4 (0.6)

(B) ADJUSTMENT OF PUMP AND GOVERNOR GUIDE SLEEVE TRAVEL

Control lever position	: Free
Speed-min -1 (rpm)	: 800
Control rack travel in mm	: 0.3-0.7

1. MAXIMUM SPEED CONTROL (RATED SPEED) (without supplementry idling spring)

Control lever position	:	59.0±4.0°
Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Control rack travel in mm	:	–
Speed-min -1 (rpm)	:	1000
Boost pressure in bar	:	–
Control rack travel in mm	:	12.95 – 13.05
Speed-min -1 (rpm)	:	1040 – 1050
Boost pressure in bar	:	–
Control rack travel in mm	:	12.0
Speed-min -1 (rpm)	:	1075–1095
Boost pressure in bar	:	–
Control rack travel in mm	:	4.0
Speed-min -1 (rpm)	:	1250
Boost pressure in bar	:	–
Control rack travel in mm	:	0.3-1.4

2. FULL LOAD DELIVERY

Speed-min -1 (rpm)	:	1000
Boost pressure in bar	:	–
Control rack travel in mm	:	12.95 – 13.05
Delivery quantity(x)	:	29.25 – 29.75 (28.5 – 30.5) in cm³/500 strokes
Maximum spread in cm³	:	1.3(2.0)

3. TORQUE CONTROL

Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Control rack travel in mm	:	–
Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Control rack travel in mm	:	–
Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Control rack travel in mm	:	–
Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Control rack travel in mm	:	–
Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Control rack travel in mm	:	–
Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Control rack travel in mm	:	–
Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Control rack travel in mm	:	–

4. COURSE OF DELIVERY

Speed-min -1 (rpm)	:	600
Boost pressure in bar	:	–
Delivery quantity(x)	:	24.75–26.25 (24.0 –27.0) in cm³/500 strokes
Maximum spread in cm³	:	1.8(3.5)
Speed-min -1 (rpm)	:	800
Boost pressure in bar	:	–
Delivery quantity(x)	:	26.25–27.75 (25.5–28.5) in cm³/500 strokes
Maximum spread in cm³	:	1.8(3.5)
Speed-min -1 (rpm)	:	–
Boost pressure in bar	:	–
Delivery quantity(x) in cm³/500 strokes	:	–
Maximum spread in cm³	:	–
Speed-min -1 (rpm)	:	–
Control rack travel in mm	:	–
Delivery quantity(x) in cm³/500 strokes	:	–
Maximum spread in cm³	:	–

5. IDLING SPEED CONTROL (RATED SPEED)

Control lever position	:	26.0±4.0°
Speed-min -1 (rpm)	:	375
Control rack travel in mm	:	4.9–5.1
Speed-min -1 (rpm)	:	100
Control rack travel in mm	:	Minimum 19.0
Speed-min -1 (rpm)	:	375
Control rack travel in mm	:	4.9–5.1
Speed-min -1 (rpm)	:	460–520
Control rack travel in mm	:	2.0

6. MAXIMUM SPEED CONTROL (RATED SPEED)

(with supplementary idling spring)

Speed-min -1 (rpm)	:	–
Control rack travel in mm	:	–

7. GOVERNOR CUTTING IN SPEED

Speed-min -1 (rpm)	:	1040-1050
Boost pressure in bar	:	–
Control rack travel in mm	:	12.0

While over checking ,if the cutting speed is above the rated speed and if,the delivery values are within the overchecking tolerance control rack remains at full load position even at 50 min (rpm) less than the rated speed the cutting-in speed should be declared OK.

8. DEGREE OF IRREGULARY

Speed-min -1 (rpm)	:	1085–1115
Boost pressure in bar	:	–
Control rack travel in mm	:	4.0”
No of notches	:	17.0

9. STARTING TRAVEL

Speed-min -1 (rpm)	:	–
Control rack travel in mm	:	–
Delivery quantity(x) in cm³/500 strokes	:	–

10. STARTING FUEL DELIVERY

Speed-min -1 (rpm)	:	100
Control rack travel in mm	:	13.25–13.75
Delivery quantity(x) in cm³/100 strokes	:	–

Note:

1. Sl.No.of the operations indicate the sequence of operations. 3.(x):Average of the cylinders
2. Values given in brackets are overchecking values

Applicable only for BOSCH and MICO Test benches

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Section P
Flywheel and Flywheel Housing

Alignment of the Flywheel Housing and Flywheel

It is most important that the flywheel housing be correctly aligned with the crankshaft. Misalignment may give rise to difficulty in changing gear, etc. If the housing has been removed, as is necessary for a complete overhaul, the greatest care must be taken on replacement to ensure accuracy of alignment. The appropriate procedure is as follows:-

See that the face of both the rear of the cylinder block and flywheel housing are perfectly clean and free from burrs.

Set the housing on to the studs and tighten, but not oversight so as to allow adjustment.

Alignment of the Flywheel Housing Bore

Secure the base of a dial gauge to the flange of the crankshaft.

Set the needle of the gauge to the inside of the bored hole in the flywheel housing.

Turn the crankshaft and check that this is truly central. The housing is adjusted until it is central.

For convenience in turning the engine it is advisable to release (but not remove) the nuts holding the atomisers in place.

The flywheel housing bore should be truly central with the crankshaft within the limits given in the table (total indicator reading).

Alignment of the Flywheel Housing Face

With the face of the "dial gauge" still bolted to the crankshaft flange, adjust the "dial" so as to set the needle against the vertical machined face of the flywheel housing, and, again turning the crankshaft, check that this face is perpendicular to the crankshaft axis. When carrying out this check, the crankshaft should be pressed forward to take up end float.

This facing should be within the limits given in the table (total indicator reading) of being truly at right angles to the crankshaft axis.

All adjustments to bring the flywheel housing within the limits must be on the flywheel housing and under NO CONDITIONS must the rear of the cylinder block be interfered with.

When the housing is properly aligned to the above limits, tighten the securing nuts evenly.

Ream the dowel holes and fit the correct length and size dowels.

Fitting Flywheel and Checking Alignment

With the flywheel and crankshaft flange perfectly clean and free from burrs and with two suitable guide studs fitted in the crankshaft flange, position the flywheel on the crankshaft.

Insert the setscrews complete with locking plates into the flywheel holes and tighten evenly.

Secure the base of the dial gauge to the flywheel housing. With the flywheel at top center, set the needle of the gauge on the periphery at T.D.C.

Turn the crankshaft and check the dial, the flywheel should run truly within 0.012 inch (0.30mm) [total indicator reading].

With the base of the dial gauge still bolted to the flywheel housing, adjust the clock so as to set the needle against the vertical machined face of the flywheel.

Again turn the crankshaft and check the dial. The flywheel should be truly at right angles to the crankshaft axis within the limit of 0.001 inch (0,025 mm) per inch (25.4 mm) of flywheel radius from the crankshaft axis to the clock gauge plunger (total indicator reading).

When the flywheel has been checked for correct alignment, lock setscrews with locking plates.

Finally grease the spigot ball race if fitted.

LIMITS FOR FLYWHEEL /HOUSING ALIGNMENT

Housing Dia		
Up to to 14 $^{1}/_{4}$ inch (362 mm)	....	0.006 inch (0.15 mm)
Over 14 $^{1}/_{4}$ inch (362 mm) to 20 $^{1}/_{8}$ inch (511 mm)	....	0.008 inch (0.20 mm)
Over 20 $^{1}/_{8}$ inch (511 rnm) to 25 $^{1}/_{2}$ inch (648 mm)	....	0.010 inch (0.25 mm)
Over 25 $^{1}/_{2}$ inch (648 mm) to 31 inch (789 mm)	....	0.012 inch (0.30 mm)

SECTION Q
LUBRICATING OIL SPECIFICATION

Use only a good quality lubricating oil to the relevant specification as shown in the table below.

Attention : The type of lubricating oil to be used may be affected by the quality of the fuel which is available.

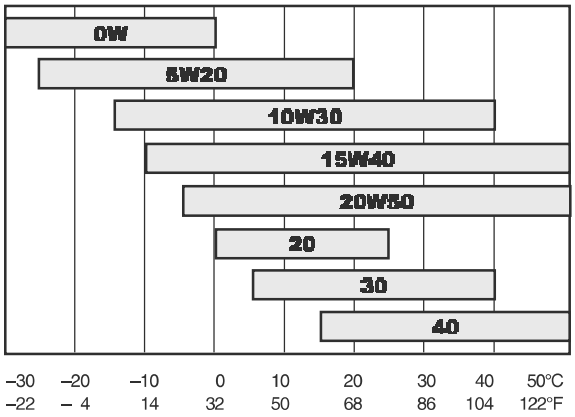
Always ensure that the correct viscosity grade of lubricating oil is used for the ambient temperature range in which the engine will run as shown in the chart below.

Lubricating oil specification

Engine Type	Specifications	
	API CCSE	API CDSE MIL-L-2104C CCMC D4
Naturally aspirated.	1	1 (1)
Naturally aspirated engines in heavy duty earthmoving equipment.		1
Turbocharged.		1

(1) Not recommended for the first 25 / 50 hours of operation, nor for light load applications.

Recommended SAE viscosity grades



FUEL SPECIFICATION

To get the correct power and performance from your engine, use good quality fuel. The recommended fuel specification for S 325.3 engines is indicated below :

Cetane number	:	45 minimum
Sulphur	:	0.2% of mass, maximum
Viscosity	:	2.5/4.5 centistokes at 40°C
Distillation	:	86% at 350°C
Density	:	0.835 / 0.855 kg/litre

Cetane Number :

Indicates ignition performance. A fuel with a low cetane number can cause cold start problems and affect combustion.

Viscosity :

Is the resistance to flow and engine performance can be affected if it is outside the limits.

Density :

A lower density reduces engine power, a higher density increases engine power and exhaust smoke.

Sulphur :

A high sulphur content can cause engine wear. Where only high sulphur fuels are available, it is necessary to use a highly alkaline lubricating oil in the engine or to renew the lubricating oil more frequently.

Distillation :

This is an indication of the mixture of different hydrocarbons in the fuel. A high ratio of light-weight hydrocarbons can affect the combusion characteristics.

Low temperature fuels :

Special winter fuels may be available for engine operation at temperatures below 0°C (32 °F). These fuels have a lower viscosity and also limit the wax formation in the fuel at low temperatures. If was formation occurs, this could stop the fuel flow through the filter.

APPENDIX I

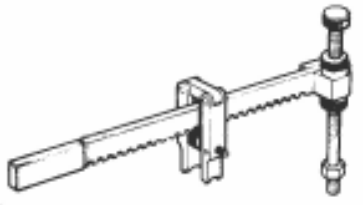
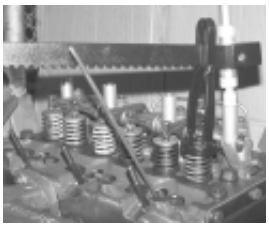
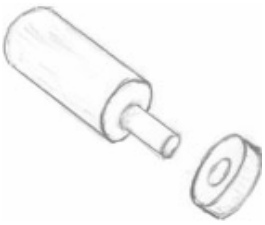
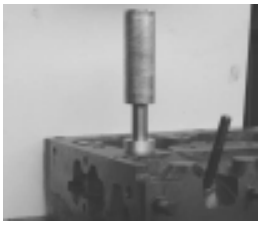
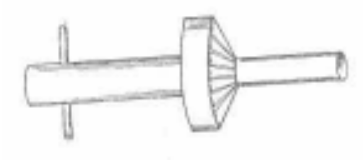
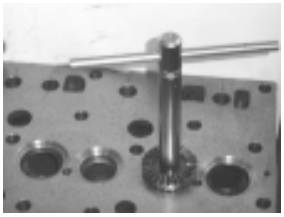
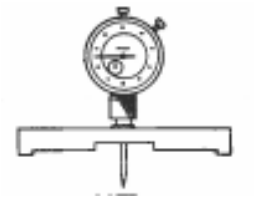
ILLUSTRATION	DESCRIPTION	TOOL NUMBER& APPLCATION
	Cylinder head valve spring compressor with adaptor	 SER 285
	Valve guide remover and replacer (Make use of screw or arbor press)	 SER 286
	Valve stem seal replacer	SER 287
	Valve seat cutter	 SER 294
	Piston height and valve depth gauge	SER 349
Replacer Remover	Cylinder liner remover/replacer adaptors suitable for liners of 3.6 inch dia. (Make use of hydraulic press)	SER 295

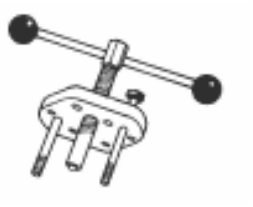
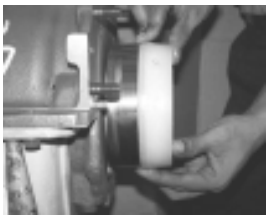
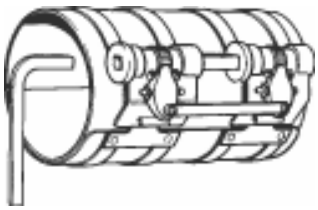
ILLUSTRATION	DESCRIPTION	TOOL NUMBER & APPLICATION
	Timing cover centraliser	SER 290
	Timing cover oil seal replacer	SER 291
	Basic puller	SER 344
	Crankshaft rear end oil seal replacer (Lip type oil seal)	 SER 343
	Piston ring compressor	SER 348
	Oil filter remover	SER 347

ILLUSTRATION	DESCRIPTION	TOOL NUMBER & APPLICATION
	Used for checking pump timing : (Applicable for In-line pump) Fuel pump spill pipe supplied with gravity tank, connecting banjo and pipe (Used for checking spill timing)	 SER 289
	Compressor tester	 SER 285
	Angle gauge	 SER 292